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TWENTY-FOURTH ANNUAL REPORT
OF
THE LOCAL GOVERNMENT BOARD,
1894—95.

S U P P L E M E N T

IN CONTINUATION OF THE

REPORT OF THE MEDICAL OFFICER

For 1894-95.

ON OYSTER CULTURE IN RELATION
TO DISEASE.

Presented to both Houses of Parliament by Command of Her Majesty.



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PUBLIC HEALTH.

REPORT AND PAPERS

ON THE

CULTIVATION AND STORAGE OF

**OYSTERS AND CERTAIN OTHER
MOLLUSCS**

**IN RELATION TO THE OCCURRENCE OF
DISEASE IN MAN;**

SUBMITTED BY THE

MEDICAL OFFICER

OF

THE LOCAL GOVERNMENT BOARD.

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R E P O R T.

TO THE RIGHT HONOURABLE HENRY CHAPLIN, M.P.,
PRESIDENT OF THE LOCAL GOVERNMENT
BOARD.

SIR,

IT has for many years been matter of belief among competent observers that the infection of certain diseases, notably that of enteric or typhoid fever, is at times communicated to the human subject as the result of the consumption of certain forms of uncooked molluscs, notably oysters. And in the Report, "On Cholera in England in 1893,"* which I had the honour of submitting to the Board in December 1894, I expressed my conviction that the distribution of shell-fish from Cleethorpes and Grimsby as a centre, had been concerned in the diffusion of scattered cases of cholera over a somewhat wide area of England. This view was then held to derive support from the fact that oysters and other molluscs at Cleethorpes and Grimsby were so deposited and stored as to be almost necessarily bathed each tide with the effluent of sewers, at that time receiving cholera discharges; and I maintained that so long as the oyster trade of those places was carried on under conditions which might at any time involve risk of the fouling of such shell-fish with the excreta of persons suffering from diseases of the type of cholera and enteric fever, so long would it be impossible to assert that their use as an article of diet was not concerned in the production of those diseases.

I, at the same time, indicated that there was evidence to show that conditions, such as were observed in connexion with the oyster trade of Cleethorpes and Grimsby, were by no means limited to the mouth of the Humber; and having regard to the facts which had then already come, and were still being brought under the notice of the Board, it was decided early in 1895 that the Medical Department should undertake a comprehensive inquiry into the circumstances under which molluscs are cultivated and stored along our coasts, and that this inquiry should be supplemented by bacteriological study as to the life processes of certain pathogenic micro-organisms in relation to oysters.

In the meantime that which had heretofore been mainly matter of belief, often confident belief, came to be expressed by observers, both in this country and abroad, as one of definite conviction. Occurrences of enteric fever were, after careful investigation, unhesitatingly ascribed to the consumption of raw

* Reports and Papers on Cholera in England in 1893; with an Introduction by the Medical Officer of the Local Government Board (C.—7539). 1894.

oysters; and Sir William Broadbent, in this country, felt it his duty in January of last year to announce, through one of the principal medical journals of England, that "the evidence of "communication of typhoid" by means of oysters had come to be "of such a character as to produce conviction" in his mind.*

About the same date we received in this country the first account which Professor W. H. Conn had submitted to the State Board of Health of Connecticut, U.S.A., on an "Oyster "Epidemic of Typhoid at Wesleyan University, Middletown, "Connecticut"; in which some 26 cases of that disease were traced with great skill and precision to the consumption of raw oysters which had had opportunity of becoming specifically contaminated by sewage from a private sewer which must be regarded as delivering, at the time, the discharges of typhoid patients into the mouth of a creek within a distance ranging from 250 to 300 feet of a bed where oysters were deposited to "fatten." Professor Conn, referring to the circumstances of this outbreak, says: "If one had planned beforehand a series of "experiments designed to prove the possibility of oysters as "distributing typhoid, it would hardly have been possible to "have desired a more satisfactory series of conditions than those "which have attained in this outbreak." And, after summarising the facts elicited, he adds in his final and more detailed report: "These facts, taken together, form a chain of evidence "practically complete at every point, and leaving no room for "doubt. Whatever may be said in regard to oysters in general, "the Wesleyan outbreak of typhoid was caused by a special lot "of contaminated oysters." This report is reproduced in Appendix No. 3 to this volume; and those who are conversant with the nature of the evidence deemed necessary to proof in the case of epidemiological investigations, will not fail to recognise that Professor Conn supplies, in the facts which he records, ample justification for the words which he uses where he states:—"One thing is sure: the public health is placed in "jeopardy when oyster dealers, for the sake of producing "plumpness, place oysters in the mouths of fresh-water creeks "in close proximity to sewers."

From this date forward other similar opinions have been formulated and expressed by medical practitioners and scientific bodies; one of the latest emanating from a Special Commission appointed by the Académie de Médecine in Paris to study and report on this subject.

At a meeting held on June 2nd, 1896, the Académie had received a communication by Dr. Chantemesse entitled, "Oysters "and Typhoid Fever."† In his paper Dr. Chantemesse recorded the following facts: After the complete absence from the little

* Note on the transmission of the Infection of Typhoid Fever by Oysters, by Sir William Broadbent, Bart., M D., F.R.C.P. "British Medical Journal," January 12th, 1895, p. 61.

† Bulletin de l'Académie de Médecine, Séance du 2 juin 1896. No. 22.

town of Saint André-de Sangoins, in the Mediterranean Department of Hérault, of typhoid or enteric fever for about a year; a barrel of oysters was received in the town on February 15th, the contents being eaten raw by 14 persons living in six houses. These oysters came from Cette, a port on the coast of the same Department; and, according to the Commission subsequently appointed, the oysters in question had been stored in waters highly contaminated with sewage. All the 14 persons who partook of the oysters were taken ill, whereas other members of the same households, including servants, who took no oysters, remained well. Of the 14 persons attacked, eight suffered from such symptoms as abdominal pain, vomiting, diarrhœa, loss of appetite, and general malaise. Four others, who were young, and who had only sparingly eaten of the oysters, were attacked with symptoms of greater severity, and lasting from a fortnight to 25 days; these symptoms including dysenteric diarrhœa, swelled abdomen (painful on pressure), great prostration, and bowel discharges described as infective. The remaining two persons, aged 21 years and 20 years respectively, suffered from exceptionally severe attacks of enteric fever, one case terminating fatally. This occurrence was, in Dr. Chantemesse's opinion, so characteristic of others held to have been related to the consumption of molluscs that he set himself to ascertain how far there was evidence that oysters purchased from the principal merchants of Paris, and professedly derived from different layings and countries, could be regarded as capable of bringing about similar results. The oysters collected for this purpose, and which appeared to be in every respect in excellent condition, were submitted to bacteriological examination; and amongst the numerous micro-organisms which they exhibited, colon bacilli were found in goodly number. Some of these oysters were then placed in sea water which had been intentionally contaminated with typhoid discharges and with the "typhoid bacillus;" and after remaining under these circumstances for 24 hours, they were taken out and kept for a further period of the same duration, this being held fairly to represent the period commonly elapsing between their removal from the oyster layings or ponds and their consumption as food. The oysters which were alive and quite normal in appearance, were then submitted to bacteriological examination, with the result that living colon bacilli and also typhoid bacilli could be recovered both from the "liquor" and from the bodies of the oysters. Dr. Chantemesse concludes his paper, which I have reproduced in Appendix No. 4, by suggesting that the fattening beds, &c., which he refers to as being mainly placed along the coast line, at the mouths of rivers, of canals, and of streams, which serve to carry away germs and dejections of every description, should be subjected to restrictions, in much the same way as is done—presumably in France—as regards certain other food supplies; and he adds that if it should be found impossible to prevent the contamination of the layings, the

oysters ought to be placed for a period of "several weeks before consumption" in sea water, which would admit of their freeing themselves from their impurities. There is, indeed, he significantly says, in the present practice, a danger which is real and grave. He adds, "it is one that can be obviated." This paper, together with one by Mons. Joannes Chatin (see Appendix No. 4), which dealt largely with the physiology of oysters,* led to the appointment of the Special Commission referred to, and on the Report of that Commission a special resolution was adopted by the Académie, to which reference will be made later on.

From the facts thus far set out, it will be seen that the decision of the Board to institute inquiry into the conditions of oyster cultivation and storage along the coast of England and Wales, soon found a much wider justification than that which had to do with our own experiences in this country. It is, however, with these latter experiences that this report is primarily concerned, and I now proceed to comment on the principal facts elicited as the result of Dr. Bulstrode's inquiry, and on the bearing upon these facts of the bacteriological investigations which have been made by Dr. Klein.

Dr. Bulstrode's inquiries, which are reported on in Appendix No. 1, extended to every part of the coast line of England and Wales where it could be ascertained that the cultivation or storage of oysters was carried on for trade purposes; and even some private layings were visited. These investigations involved, amongst other things, a number of general considerations which he sets out in an introductory chapter, and which include questions relating to such matters as the anatomy and physiology of the oyster in so far as these had concern with this inquiry, the extent of our oyster industry, the legal provisions affecting the oyster fisheries, and the actual processes involved in the cultivation and storage of oysters on our coast. They also involved a series of local inspections of a detailed character. In some places these inspections extended over several days, and in others special supplementary visits were paid, so that the several circumstances might be studied under varying conditions of tide and wind. Observations were also made, with a view of tracing, as far as was practicable, the direction of the currents at different states of the tide. And certain interesting considerations are discussed as to "green oysters," at a few points along our coast.

The record of these local inspections commences with the fisheries on the north of the Thames estuary, it proceeds from that point up the eastern and down the western coasts, then along the southern coast, and concludes with the south bank of the Thames estuary. A separate report has been written on each place visited, and in the majority of instances one or

* Sur la Nocivité des Huîtres, par M. Joannes Chatin. Bulletin de l'Académie de Médecine. Séance du 9 juin 1896.

more maps have been appended to the reports in order that the approximate position of the oyster layings, ponds, or pits in relation to any possible sources of pollution may be made obvious at a glance.

Very largely for the purposes of convenience, especially in the matters of accessibility and of the facility for procuring labour at a reasonable cost, the cultivation of oysters is carried on at points along our coast which are near to towns or villages more or less populous; and for reasons which have concern with the developmental processes in the oyster, a special preference is given, especially during the later stages of its growth, to river estuaries and their neighbourhood. A broad distinction can, however, as a general rule be made between such "layings" or parts of "layings" where oysters—whether native spat, or oysters brought from elsewhere on our coasts, or from abroad—are laid for further growth and development; and others which are used as fattening beds, along with "storage-ponds," from which oysters are, as a rule, dredged up or taken for despatch to market. But Dr. Bulstrode gives ample grounds for the view which he expresses that the risk of the fouling or the specific infection of oysters is, as a rule, of much more pressing importance as regards such parts of layings as are used as fattening beds and as regards ponds and pits resorted to for storage purposes, than it is as regards other layings from which oysters are not despatched direct to market. Both in his description of the local circumstances, and in his maps, he differentiates between the two; but he takes care to indicate where the differentiation is but little or not at all applicable.

Only a few of the layings, fattening beds, or storage ponds round our coast can be regarded as theoretically free from every possible chance of sewage pollution. But as regards the majority of them any such polluting matter becomes mixed with so vast a bulk of water that it is difficult to see how the layings can be subjected to anything approaching substantial risk of deleterious influence. There are, however, exceptions to this rule; and I propose, in the first instance, to refer to such layings, or parts of layings, as are used for fattening, and which must be regarded as exposed to risk of danger; and next to advert to places used for the purposes of temporary storage, and which are similarly situated. I shall then call attention to layings and storage ponds which may be regarded as practically, or even altogether, free from the risk of sewage pollution.

At Southend, where there are two layings, it was found that at the one to the west of the pier the oysters are placed between two principal sewer outfalls, to say nothing of the proximity of minor outfalls, at a point where the sea bottom and the matters floating on the surface afford the most obvious proof that the conditions are filthy in the extreme. Indeed, the only plea that it seemed possible to raise in justification of the circumstances discovered was that the oysters in question, and which are

transmitted direct to market, were deep-sea oysters, which are mainly used for sauce, and, as such, are not eaten raw. This plea is discussed by Dr. Bulstrode in a footnote. From the second laying, to the east of the pier, ordinary edible oysters are obtained for local consumption; and this laying may perhaps be regarded as less likely to be contaminated by the contents of a third main sewer and of the minor outfalls referred to, than is the case with the western one; but the oysters derived from it can hardly fail to share some, at least, of the risk to which the other layings here are subjected. These Southend oysters would appear to be placed on sale direct from the layings, except indeed such of them as are temporarily stored in floating boxes south of the pier pavilion.* At this point one "float" was discovered within 36 yards only of a pipe from one of the lavatory closets, which during the summer are open to thousands of persons. The owner of these layings admitted, as regards the western laying, that it "was perhaps more exposed to sewage than any other in England," and I am able to agree with him that, so far as this inquiry extends, the laying in question has an almost unrivalled pre-eminence in this respect.

Another set of oyster layings which deserve especial attention on the ground that oysters are despatched from them direct to market, are those situated at Cleethorpes on the southern shore of the mouth of the Humber. These layings, which constitute one of the greatest of the centres from which oysters are distributed over England, are situated between two sewer outfalls from Cleethorpes, one outfall being about a mile and a half above, and the other about three-quarters of a mile below, the layings; these two sewers together serving a population of about 7,500. Somewhat over half a mile higher up the Humber than the first-named sewer is the main sewer outfall for Great Grimsby, and about a mile still higher up is the second outfall

* Dr. R. Bruce Low, in reporting, in April last, to the Local Government Board, on a "Recent Prevalence of Infectious Diseases in the Borough of Southend," refers to the fact that, locally, attacks of enteric fever had been now and again referred to oysters from this foreshore. He proceeds:—

"Some oyster beds lie off shore to the east and to the west of the pier. On the summer bank holidays it has been found difficult to keep day trippers hailing from the East End of London from helping themselves to the oysters at low water. A watchman has been told off during the last few years on each August bank holiday, to protect certain oyster beds and to warn off intruders. The proprietors of the oyster beds usually, on these occasions, present the watchman with a quantity of oysters to take home with him. I have been informed that a watchman employed on bank holiday, August 6th, 1894, gave some of his oysters to a family with whom he was on friendly terms. Two members of this family who had eaten the oysters were subsequently notified ill of enteric fever, one on August 26th, the other on August 30th, and their medical attendant attributed their illness to eating these oysters. After bank holiday, August 5th, 1895, the same watchman again brought back a stock of oysters, and gave them to various friends; on this occasion three persons who had eaten the oysters were attacked later on by enteric fever, and were notified respectively on August 29th, September 3rd, and September 5th. Another friend who had eaten some of these oysters, and three comrades of the watchman who had also partaken of them, all had attacks of diarrhœa and sickness shortly after eating the oysters. The oysters, I was told, were taken from beds three-quarters of a mile from the shore to the east of the pier, but not far from the Castle sewer outfall."

for the Great Grimsby sewage. These two outfalls together serve a population estimated at some 60,000. Dr. Bulstrode, however, takes care to indicate a number of points which have been suggested, or may be alleged against the view that these layings are liable to risk of sewage contamination. He explains how the sewage of Grimsby is dammed back in the sewers at the last half of the flood tide, and the first half of the ebb tide; he indicates, as regards the main outfall from Cleethorpes, that by reason of similar arrangements, and of the existence of a sand bank, the sewage is locally said to be diverted away from the layings towards midstream; and he recalls the fact that the Humber contains at all states of the tide a vast body of water. Indeed, I may at this point call attention to the circumstance that, as regards all the localities visited in connexion with the oyster fishery, Dr. Bulstrode has been at pains to take account of every condition which he himself observed, or which was brought under his notice, which had, or was alleged to have, even a remote influence in securing the fisheries against pollutions to which they, at first sight, seemed to be subjected. But after taking all into account, he is unable to regard the Cleethorpes layings as free from risk, and this view is the more important because vast numbers of the oysters are conveyed direct from them to the market. I shall later on advert to the storage at Grimsby of oysters from this and other layings, for the purposes of the Grimsby trade.

Another series of layings, some of them are used as fattening beds, which must be regularly washed with water abounding in sewage refuse, are situated in the Medina, in the Isle of Wight. It seems almost beyond comprehension how any one could venture to "fatten" oysters for human consumption in a river estuary such as this, which is fouled above the layings by the crude sewage of Newport, with its 10,000 inhabitants, by the effluent from the neighbouring prison and barracks, and by the overflow from the workhouse cesspool; and which receives into it immediately below the layings, the contents of eight other sewer and drain outfalls from East Cowes and West Cowes. The layings in the Penryn River, Cornwall, and those in Brightlingsea Creek, in Essex, also call for especial notice in connexion with the obvious risk of sewage pollution. At Brightlingsea, this risk has more than once been drawn attention to by the local health officer. The layings in the South Channel, off Southwick, near Shoreham, are similarly exposed to sewage; and, in a minor degree, on account of the great bulk of water there in question, such layings as those in the Menai Straits, come under suspicion. From most, if not all, of these layings oysters are despatched direct to market.

Happily, conditions such as those ascertained to exist at Southend, Cleethorpes, and the Medina River, and at some of the other places specified, are, as I have said, by no means universal as regards the oyster layings along our shores; and it is with satisfaction that I can turn, by way of contrast, to some

of our most celebrated fisheries on the coasts of Essex and Kent. Thus, the only remaining pollution to which such of the layings as are used for fattening beds in the River Crouch were formerly subjected, has been removed since Dr. Bulstrode's visit, and they may now be regarded as "free from risk of sewage contamination." Much the same freedom from risk applies to the layings in the River Roach, and it would take but little to render them altogether secure. The "market" layings in the Blackwater River may also probably be regarded as but little subject to sewage pollution, having regard to the width of the stream and its great bulk of water, and to the fact that the effluent from Maldon enters the river some 6 miles above the nearest point of the layings. As regards the layings in the bed of the Colne, Dr. Bulstrode points out that, although the Colchester sewage is subjected to careful treatment before the effluent enters the river, and although the outfall for this effluent is 5 miles away from the nearest oyster layings, no oysters should be despatched to market direct from these layings, owing to the comparatively concentrated condition of the sewage effluent at low water, and to the additional pollution to which the river is subjected at Wivenhoe and Rowhedge. Other layings in creeks opening on to the west bank of the Colne are deemed to be practically free from risk.

With regard to the well known "Whitstable" oyster fisheries, which are in the hands of two separate Companies, it should be noted, in the first place, that both of these Companies possess storage ponds near Hayling Island, in Hampshire. These ponds which are mainly used for "wintering" purposes, thus come to resemble layings; they appear to be well situated, and no reason was found for regarding them as otherwise than free from risk of contamination by sewage. One of these Companies possesses two layings at the mouth of the Swale, off Whitstable, from which oysters are despatched direct to market. One laying is over 3 miles out at sea, and hardly calls for comment as to risk of sewage contamination. The second one is more within the river mouth, and lies somewhat over a mile and a quarter from the nearest outfall of the Whitstable sewage. So far as could be learned, as the result of both investigation and experiment on the spot, the sewage of Whitstable tends to pass directly eastwards and away from the layings; and having regard to the enormous dilution with sea water that must take place, Dr. Bulstrode arrived at the conclusion that both these layings should be regarded as "practically free from liability to contamination "with Whitstable sewage." The layings of the other Oyster Company are also well out to sea; and oysters are likewise sent from them direct to market. With regard to their risk of exposure to sewage, they are practically in the same position as the other layings off the Swale. The Whitstable fisheries will call for further consideration when I come to discuss the question of the storage of oysters for market.

Between the two extremes of which I have given examples, the oyster layings along our coast exhibit varying degrees of

exposure to sewage pollution. But in the majority of instances where the chances of pollution appear at first sight to be the greatest, when this is judged by reason of proximity of layings to sewage and drain outfalls, or by reason of currents and eddies tending to carry such pollution to them from more distant sources, the oysters in question are not consumed until some time after they have been taken up from the layings. So also, the dilution of the sewage is not infrequently very considerable; at times, indeed, so considerable that the chances of sewage contamination hardly call for notice.

This leads to the consideration of the means of storage whether in beds, ponds, pits, or otherwise—localities and receptacles in which oysters are admittedly placed in preparation for, and pending despatch to market. As already implied, this has turned out to be by far the most important matter which has come under review in the course of this inquiry. In some instances the means of storage immediately antecedent to the distribution of oysters for human consumption must come under distinct condemnation. Thus, the floating boxes, already referred to at Southend Pier, come definitely within this class. Again, an isolated set of storage pits belonging to a private merchant, at the mouth of the Blackwater, was found within 43 yards of the point at which the drainage of 20 houses is discharged. So also, at Wivenhoe it is impossible to see how the oysters there stored in pits can escape contamination by sewage. The means for the storage of oysters in the Fish Dock at Grimsby are particularly offensive and dangerous. Setting aside all question of the washing back into the dock of the large body of highly diluted sewage, which enters the Humber above and below the dock gates, the dock itself receives human excreta into its confined waters in no inconsiderable quantity; these waters, indeed, were found to be “dirty in a high degree;” and a public urinal has been arranged so as to empty itself near one of the oyster floats. “In a word the Grimsby Fish Docks,” says Dr. Bulstrode, “must be pronounced as an altogether improper place for the “storage of oysters.” I would further point out that the arrangements as to oyster culture and storage at the mouth of the Humber remain what they were when the facts elicited during the cholera and enteric fever prevalences of 1893 in these places gave prominence to the question of the relation of oysters to the production of disease, and so contributed to the issue of the instructions on which this report is based.

At this point it may be well to consider what it is that is to be regarded as the test of risk in this matter; for it is reported that the Town Council of Grimsby procured analyses of their dock waters, and that the expert, though finding bacteriological evidence of all sorts of pollution, detected no organisms which did not present characteristics distinguishing them from the cholera bacillus, and from the bacillus of typhoid fever. Few persons, I imagine, will be inclined to attach importance to such evidence, or rather to such absence of evidence. Dealing as we do, both

in the case of enteric fever and of cholera, with an infection of a particulate character, we are concerned not with some material which is uniformly distributed throughout the whole body of water to which it has gained access, after the manner of a chemical solution, but with microscopic bodies which may be widely separated, and which, though they may at one time tend to multiply and crowd together in microscopic masses, tend at another time to loss of vitality and to destruction. These are mingled with waters after the manner of a mechanical mixture, and occasional samples of water, whether selected or not, must often fail to exhibit them. Even when the contents of a certain well have been conclusively proved to serve as the vehicle of enteric fever, it has often been found impossible to find Eberth's bacillus in many a gallon of the implicated water, whereas when a smaller quantity has been collected drop by drop throughout a continuous period of 24 or 48 hours, unmistakable evidence of the presence of this bacillus has more than once been forthcoming. The sanitary history of this country has been one in which progress, or want of progress, has been largely dependent on the intelligent apprehension of, or the inability to apprehend, two important factors. Firstly, that in estimating the degrees in hurtfulness of filth, a foremost place must be assigned to that which is derived from the human intestinal canal; and secondly, that since we can never know that the form of filth in question is free from the specific matter of disease, we should always regard such filth as potentially diseased and infective. Thousands of lives have been saved by applying these principles to our water supplies; it still remains to apply them, in but too many places, to the preparation of oysters for human consumption.

But, to resume. It would be difficult to find much worse conditions than those under which certain storage pits are placed at Poole. A number of small sewer or drain outfalls empty into the Quay Channel which delivers its waters over the pits at flood tide; but, besides this a watercloset drain delivers on to the foreshore midway between, and not many yards from two sets of pits, whilst one of the sets has still nearer to it six other drain outlets. At Warsash, above the junction of the Hamble River with Southampton Water, a sewer was found opening out just between two oyster ponds. Again, at Emsworth, near Havant, a sewer and certain drain outfalls have been conveyed into the middle of a group of oyster pits; and matters are but little better at Bosham. So also, at Southwick, oysters from which place have been alleged to have had concern with enteric fever in Brighton, there are oyster ponds which are flanked on either side with sewers discharging into the River Adur; these ponds are also exposed to sewage contamination by reason of other sewer outfalls a little higher up the river.

A superficial glance at the maps with which Dr. Bulstrode's report is illustrated, might well lead to the hasty conclusion that sewage is deemed to be of value—if indeed it is not

actually sought for—in connexion with the processes of oyster fattening and storage. But, whilst any such inference would probably be altogether misleading, it is impossible not to agree with Dr Bulstrode, when he says that “at certain places along our coasts no care whatever has been exercised in the selection of localities for fattening beds, and for storage ponds, in order to ensure that oysters should be reasonably free from risk of sewage pollution.” In the selection of such layings, fattening beds, storage pits, &c., the convenience of easy access has evidently had much weight, and since the fattening process is, in all probability, largely dependent on the supply to the oysters of minute organisms, to which they have heretofore been but little, if at all, accustomed, and which are carried to them by means of fresh water, the estuaries of rivers, where the required admixture of fresh and sea water is obtained, have become favourite fattening grounds. And since the law relating to the pollution of rivers exempts from its operation “rivers,” &c., “emptying directly into the sea, or tidal waters which have not been determined to be streams” by Order as provided for in the Statute, it comes about that foreshores and river mouths are often made to receive crude sewage.

When, however, the requisite conditions for oyster culture and fattening can be found at spots where there is little or no risk of sewage contamination, advantage has evidently been taken of them; and it is a matter of satisfaction to find that some of the most esteemed of English oysters are not only laid down for growth and development, but are also fattened and stored, in waters where risk of sewage pollution is either all but inappreciable or altogether absent. Such immunity from risk may be taken to apply in the case of the fattening beds and storage pits in the River Crouch; those in the River Roach are in much the same position. Indeed, it would seem that the creeks abutting on these rivers afford opportunities for preparing oysters for market which may be regarded as altogether exceptional. The majority of those in the Blackwater and its tributaries come within the same category. The fattening beds in the Pyfleet and the wintering and storage pits on Peewitt Island, which are utilised in connexion with the River Colne oyster fisheries, must also be regarded as practically free from chance of such pollution. And again, the layings and means of storage in the Helford River in Cornwall and in Newtown Estuary, Isle of Wight, take very high rank as regards the character of the waters in which they are situated. As regards the oyster fisheries opposite Whitstable at the mouth of the Swale, it would appear that the majority of the oysters despatched to market are dredged up directly from the layings which have acquired a very high reputation for fattening purposes. Both Companies, however, possess storage pits where a small number of oysters, which are not required for immediate sale, are at times deposited. Both sets of pits were visited by Dr. Bulstrode on several occasions. Those belonging to the Whitstable Oyster

Company presented a very cleanly appearance, and the fore-shore on which they are situated exhibited, on the occasion of Dr. Bulstrode's visits, no indication that the water flowing daily into them was polluted. The cleanly nature of the beach in the neighbourhood of the water intake went to confirm this impression. The Ham and Seasalter Company's pits were also found to be in a very cleanly condition, but it was not possible to speak of the water entering them in the same terms of confidence. The Company are, however, of opinion that since this water is only admitted to the pits on the flood tide when no sewage from the harbour outfall passes the intake, no risk is incurred. It could, however, have been wished that the question of risk were more completely free from doubt in this respect than appears to be the case. The pits are, however, not necessary to the operations of the Company.

I have thus endeavoured to indicate as regards the storage ponds and pits, as I had previously done as regards the layings, some which may be regarded as representing high degree of risk or absence of risk from sewage pollution. Between these extremes many grades are found along our shores. Sufficient has, however, been said to indicate that which should be avoided, and that which should be aimed at. For the rest I would refer to the details submitted in Dr. Bulstrode's report.

Up to a comparatively recent date, when the science of bacteriology came to the aid of epidemiology, and helped to confirm or to modify views that had heretofore to be mainly based on accumulation of observed facts as to the conditions under which epidemic and preventable diseases occurred from time to time, the material, which is submitted in this report, and to which I have thus far adverted, would have been accepted as abundantly sufficient to show that the consumption of uncooked oysters, which had been recently exposed to the influence of crude sewage, had, at times, concern with the production of certain specific diseases, the infection of which is largely eliminated by the alvine discharges. Enteric fever, for example, has been ascertained to have followed on the consumption of raw oysters; the interval between such consumption and the onset of the symptoms has corresponded with the incubation-period of the disease; the special incidence of the fever has been on those who were known to have partaken of the oysters, whilst others who could only be differentiated from the sufferers in that they had not partaken of the oysters, escaped; the consumption of oysters has been ascertained by a process of exclusion to have been the only medium through which such a disease could have been simultaneously communicated to the sufferers; and at times the oysters in question have been found to have had opportunity of contamination by human excreta, even by specifically infected excreta.

It is, indeed, on evidence such as this that the main progress in preventive medicine in this and other countries has, until a comparatively recent period, been based; and on such evidence

our future measures of prevention must necessarily continue to be largely based. Long before Koch's cholera vibrio, or Eberth's typhoid bacillus had been even heard of, the remarkable progress made in the prevention of cholera and of enteric fever in this country was the result of the recognition of the fact that water and food, amongst other things, which had been subject to contamination by human excreta, served as channels for the communication of the specific contagia of those diseases to man. It remains, however, to see what has been the bearing of bacteriological research upon inferences based on such facts as those to which I have adverted.

The recent investigations by Dr. Klein, which have direct bearing on the subject matter of this inquiry, may be conveniently dealt with under the following headings:—

1. The behaviour of the typhoid bacillus and of Koch's cholera vibrio in sewage and in fresh water.
2. The behaviour of the typhoid bacillus and of Koch's vibrio in sea water.
3. Oysters in experimental relation with the typhoid bacillus and Koch's vibrio.
4. The bacteria actually observed on or within oysters obtained from one and another source in this country.

Investigation in the sense of No. 1 was undertaken in ordinary course as part of the systematic inquiry instituted by the Board into the life histories of pathogenic microbes. It is reported on in detail in my Report for 1894-95, pages 407-28. Investigations Nos. 2, 3, and 4 were undertaken by Dr. Klein especially in furtherance of this oyster inquiry, and record of them in detail will be found in Appendix No. 2 to this report.

With regard to the behaviour of the typhoid bacillus in sewage, it should be remembered that this bacillus is difficult of detection in crude sewage. Even in the sewage directly obtained from a hospital containing a plurality of patients ill of enteric fever this microbe is by no means easily demonstrable. Partly the difficulty in question would seem to be due to the small amount, actual and relative, of typhoid bacilli present in any given sample of crude sewage, partly to the super-abundance in sewage of other bacteria, some of them not to be easily distinguished from the microbe of enteric fever. So, too, with Koch's cholera vibrio. It must needs, if present at all in sewage, constitute but an infinitesimal fraction of any given sample: and it will be mingled therein with a host of other bacteria which will tend to mask its presence, though this vibrio, it is true, is more easily separable in culture from allied forms than is the typhoid bacillus. On the above grounds, and especially because of their probable scarcity in any sample, bacteriological testimony as to the absence from sewage of the typhoid bacillus or of the cholera vibrio should, Dr. Klein considers, be accepted with reserve. In his view, only when several separate samples in large amount of the suspected sewage have,

under the laboratory methods of to-day, been submitted to strict and repeated scrutiny, is negative evidence in this sense to be trusted.

In adopting this attitude, Dr. Klein is not by way of denying the belief, which is commonly entertained, that sewage, as such, is hostile to the life processes of the typhoid bacillus and of the cholera vibrio, *i.e.*, that both microbes tend quickly to die out in and disappear from crude sewage. This he accepts as in the main demonstrated by the experiments of many observers, though as a result of his own experiments he would accord to the typhoid bacillus and to Koch's vibrio greater ability to persist in even pure sewage than they are usually credited with. The point upon which Dr. Klein insists is that crude sewage, whether or not it contains these or other pathogenic microbes, does not in ordinary circumstances long remain crude sewage: that sooner or later, in the process of its disposal, sewage becomes, by addition to it, and by subtraction from it of one or another material or constituent, greatly modified; and that therefore bacteria of pathogenic sort, if only they can retain their vitality for a few hours in the crude sewage into which they have become introduced, may thereafter find themselves submitted to conditions enabling them not only easily to maintain their existence, but to multiply also indefinitely, and to transmit unimpaired to their progeny their physiological, *i.e.* their hurtful properties.* And Dr. Klein shows in the papers above referred to that, experimentally, it is by no means difficult so to modify sewage in the laboratory as to render it a multiplying ground for the typhoid bacillus and for the cholera vibrio, and a medium, moreover, in which the one and the other microbe is able to subsist for many weeks.

The difficulty in identifying the typhoid bacillus and the cholera vibrio is rather enhanced than diminished when large volumes of water in which sewage specifically polluted with these microbes has become diffused are in question. Wherefore Dr. Klein maintains that bacteriological testimony as to the absence from one and another suspected water of the typhoid bacillus or of Koch's vibrio, is not to be accepted as valid unless and until large quantities of the implicated water have been repeatedly examined. Instead of testing for the one or the other microbe a few drops only of a sample, as is often done, Dr. Klein's practice is to submit on several separate occasions, 1,200 to 1,500 c.c. of the water to appropriate tests; and in this way he has again and again obtained positive results in cases where the "few drops" method had, so far as it went, in his own hands as well as in the hands of others, tended to exculpate a particular water. For the rest he is able to indicate, by an extended series of experiments, that the persistence of the

* In Dr. Klein's experiments on the physiological activities of the typhoid bacillus and of Koch's cholera vibrio, these microbes were, of course, not tested on the human subject, but on rodents.

typhoid bacillus and of Koch's vibrio in waters prepared in a laboratory depends to a far greater extent than has hitherto been supposed on the presence in, and the absence from, the water of certain ingredients. And he goes on to demonstrate as regards different sterilised "natural" waters that while some discourage, others tend to foster these microbes; that in a certain lake water, for instance, both the typhoid bacillus and Koch's vibrio could maintain themselves for several weeks, and that the latter microbe could even multiply therein with considerable vigour.

In their bearing on the oyster question the several series of experiments undertaken by Dr. Klein, as part of the Board's customary auxiliary scientific investigations, would seem to raise presumption that both the typhoid bacillus and Koch's vibrio can retain their vitality in crude sewage for a time sufficiently long, in many cases, to permit of such sewage being delivered in ordinary course on to land, or being discharged "untreated" into streams; and that, therefore, these microbes, whether or not they multiply in water to which they have gained access, are able to subsist in this medium long enough to be transported, along with the water, very considerable distances beyond the point at which they gained entry to it.

In view of the presumption that the typhoid bacillus and Koch's vibrio, whether contained in sewage polluted river water passing seaward or in crude sewage directly discharged into an estuary or into the sea, are to be credited with an opportunity of reaching the tideway in a viable condition and in possession of their physiological activities, it became important to ascertain how far the life and activities of these microbes are affected when they themselves are subjected to sustained sojourn in sea water. This matter Dr. Klein tested as follows:—

As a preliminary, several samples, 200 c.c. in each instance, of strained but non-sterilised sea water in separate flasks, were inoculated by him, some with scrapings from a "recent" agar culture of the typhoid bacillus, others with scrapings from a "recent" agar culture of Koch's vibrio; and the flasks were left at the temperature of the laboratory. At intervals of several days the water in these flasks was tested as to the presence of the one and the other microbe, by transferring increasing amounts of their contents to phenol broth and to peptone salt solution respectively, and incubating the cultures at 37° C. As a result, the typhoid bacillus was recovered from the sea water on each occasion of testing up to four weeks, and the cholera vibrio up to two weeks, from the date of inoculation of the original flasks; thus indicating, so far as the experiments went, that sea water as such, had certainly no speedy germicidal effect on either microbe. In no instance, it is true, was there suggestion that the microbe of experiment had multiplied in the sea water; rather there was indication that both the typhoid bacillus and Koch's vibrio had greatly diminished in numbers as the experiments

proceeded. Nevertheless, such of them as were recovered from the sea water at the termination of the experiment fully retained their vitality, and differed hardly at all—morphologically, culturally, or physiologically—from the stock from which in each instance they had been originally derived.

Dr. Klein's further procedures were on a larger scale, and, as will presently appear, were concerned with oysters as well as with the typhoid bacillus and Koch's vibrio. So far, however, as these microbes were concerned these experiments were in extension of those already described, differing from them only in the circumstance that the sea water in which the typhoid bacillus and Koch's vibrio were now placed was in part renewed from day to day instead of remaining, so to speak, stagnant.

A number of tanks having been set up, each capable of holding three gallons, these were filled with strained unsterilised sea water, and at the bottom of each about a dozen oysters were laid. To each of one series of tanks there was introduced the total scrapings from an agar culture of the typhoid bacillus, to each tank of another series a similar amount of agar culture of Koch's vibrio; the water in each tank being then well stirred up with a glass rod so as to distribute the microbes equally throughout the sea water. The lids of the tanks were then closed, no more culture material being at any time added; but daily, to each tank, one gallon of fresh sea water was slowly introduced, and a like quantity of its fluid contents was allowed to escape by way of an aperture at the surface of the water, and on the opposite side of the tank to that at which the fresh sea water was passing in.

The typhoid bacillus having been thus dealt with, was found at the end of two or three weeks to have considerably diminished in amount in the sea water, but was easily recoverable therefrom by a culture process in which 100 c.c. of the water of experiment were incubated at 37° C., along with an equal amount of phenolated broth. And the samples of the microbe so recovered appeared to possess full vigour; in no way—morphologically, culturally or physiologically—could they be distinguished from those of the stock whence they had been derived.

Under similar conditions, however, Koch's vibrio did not behave in all respects in a manner parallel to the typhoid bacillus. Like that microbe it failed to afford evidence of having multiplied in the sea water. It was also easily recoverable from the sea water at the end of a couple of weeks when 90 c.c. of that water were incubated with 10 c.c. peptone salt solution. But unlike the typhoid bacillus, Koch's vibrio did not remain altogether stable in the sea water in which the oysters were placed. In certain of the tanks this microbe commenced in four or five days to exhibit slight morphological change, while at the end of a couple of weeks it was found to differ culturally, in

what may be thought of as essential features, from Koch's vibrio, and at the same time was proved to be less active physiologically than in the agar culture with which the experiment was set going.

Upon the whole, therefore, Dr. Klein's investigations in this connexion, while showing that both the typhoid bacillus and Koch's vibrio may persist for some two or more weeks in sea water, also serve to indicate that whereas the former is not prone during such period to undergo any biological change or modification of its physiological activity, the latter soon tends, at any rate in the presence of oysters, not only to vary in its morphological and cultural features, but also to become despoiled in part of its hurtful properties.

The nature of Dr. Klein's testing of oysters in relation with the typhoid bacillus and Koch's vibrio, has already been indicated under the previous heading. In all, he submitted seven batches of oysters to sea water purposely infected with the typhoid bacillus, and other two batches to sea water similarly infected with Koch's vibrio. The oysters of experiment had been obtained from a number of different sources, and comprised as many separate varieties of the mollusc as was practicable in the circumstances.

Firstly, as to oysters in sea water to which typhoid bacillus had been added.—At intervals of a few days during a period in each instance of two to three weeks from the commencement of the experiment, samples of each batch of oysters were removed from the tanks, duly cleansed, as regards their exterior, under a fresh water tap, dried on a clean cloth, and opened with a sterile knife. The body of the oyster was next mashed up with the liquor that had been contained within the shells, and about $\frac{1}{4}$ c.c. of this mixture was added to phenol broth. From this broth, after incubation at 37° C. for 24 hours, phenol-gelatine plate cultures were established, and the microbes growing therein were duly submitted to the usual series of tests for the typhoid bacillus. As a result—and whether the oysters were taken from the tank as early as the fourth or as late as the seventeenth day of experiment—the typhoid bacillus was almost without exception demonstrated as present in their interior, and generally in abundance. Furthermore, the bacillus thus recovered from the material within the oyster shells differed in no way from the typhoid bacillus originally introduced into each tank; morphologically, culturally, and physiologically it proved identical with it.

There can be no doubt therefore that oysters which have been brought into sustained relation with the typhoid bacillus are liable to exhibit that microbe within the shell contents, and to retain it for a while under circumstances not only permitting its rapid multiplication when transferred again to appropriate media, but conserving at the same time its ability to manifest its hurtful properties.

Secondly, as to oysters in sea water to which Koch's vibrio had been added.—As with the typhoid bacillus so with Koch's vibrio, the oysters with their liquor are shown by Dr. Klein to exhibit the microbe. But here similarity of the reaction of the oyster towards the two micro-organisms would seem to end. Within the shell-contents Koch's vibrio appeared rapidly to undergo definite modification, in the same direction but much more rapidly than had already been found to occur to this microbe in sea water in which it had been placed along with oysters. The full extent of this modification of Koch's vibrio, and the significance to be attached thereto are receiving further study by Dr. Klein.

The purpose of Dr. Klein's inquiry as to the bacteria observed on or within oysters, was to ascertain whether microbes of pathogenic, or quasi-pathogenic, sort are discoverable on or within oysters that have seemingly been exposed to greater or less opportunity of contamination by sewage.

As matter of first instance, and by way of obtaining a standard of comparison, Dr. Klein examined a number of oysters from various sources which had presumably *not* been exposed to risk of sewage pollution; with the result that he failed to find, in oysters of this class, any bacteria which were to be thought of as having concern with sewage.

The microbes that he set himself to detect in oysters of the one and the other class were bacteria that are to be observed in water into which sewage has gained access. In this sense he gave especial attention to bacillus coli, and the typhoid bacillus. With a view of identifying these microbes in matters *external* (adhering) to the oyster, Dr. Klein collected such material by carefully brushing it from the specimen into sterile water, samples of which were then inserted into phenolated broth and incubated at 37° C. From this broth phenolated gelatine-plates were in turn set up, and the micro-organisms growing therein separated out in customary fashion. As regards the *interior of oysters* Dr. Klein made in each instance an emulsion of the body of the animal and of the liquor contained within its shells, after the manner already described, and proceeded to test samples of the mixture as before in phenolated broth and gelatine plates.

The oysters under suspicion of contamination by sewage which were made subjects of investigation by Dr. Klein, had been collected by Dr. Bulstrode in one and another locality in the course of his inspection of coast fisheries in England and Wales. It was out of question, with the sum of money at the Board's disposal for this purpose, and with the limited time at command, that samples could be tested from each separate locality in which oyster layings, fattening beds, and storage pits were to be thought of as subject, directly or indirectly, to sewage pollution. All that could be done in the circumstances was to take samples of oysters here and there, now from storage pits so situated as obviously to permit of the entry into them of

practically raw sewage ; now from oyster layings little, if at all, exposed to access of diluted sewage ; with a view to ascertaining how far bacteriology was to be trusted to distinguish between the very obviously different risk of contamination by sewage matters to which oysters of the one and the other class had been exposed.

But any expectation that by differential testing in the laboratory of samples from consignments of oysters of diverse origin, trustworthy instruction might be got as to consignments which had, and consignments which had not, come from quarters where the local oyster business was being carried on under hazardous conditions, failed to be realised. Taking the presence of *bacillus coli* on or within oysters as affording some index of recent subjection of the molluscs to sewage contamination, Dr. Klein's investigations in the above sense, though interesting and, perhaps, instructive, proved on the whole disappointing. The microbe in question was, it is true, found by him on or within a number of oysters collected in various localities from storage pits on the foreshore, so placed as to be obviously exposed to sewage discharged near by ; but on the other hand, this microbe was *not* found in relation with other oysters that had been exposed in exactly similar fashion to opportunity of sewage contamination. Moreover, the amount of *bacillus coli* detected on or within particular oysters bore no definite relation to their observed opportunities for becoming contaminated with sewage ; indeed, now and again, oysters which could only have been remotely and very indirectly exposed to contamination of the above sort were nevertheless found to contain *bacillus coli*. So, too, with reference to evidence of *specific* pollution of oysters. The typhoid bacillus, which is the accredited agent of enteric fever, was only in a single instance detected by Dr. Klein in any oyster out of a number that had been unquestionably stored in relation with sewage. The instance in question had to do with American oysters which had been stored in the "float" in the Fish Dock at Great Grimsby.

The results of Dr. Klein's investigations which bear more immediately on the culture of oysters would appear to be as follows:—1st. The cholera vibrio, and still more the typhoid bacillus, are difficult of demonstration in sewage known to have received them. 2nd. Both these organisms may persist in sea water tanks for two or more weeks, the typhoid bacillus retaining its characteristics unimpaired, whilst the cholera vibrio tends to lose them. 3rd. Oysters from sources which appeared to be free from risk of sewage contamination exhibited none of the bacteria, specific or otherwise, which are commonly regarded as being concerned with sewage. 4th. Oysters from a few out of numerous batches derived from sources where they did appear to be exposed to risk of sewage contamination were found to exhibit colon bacilli ; a circumstance which, notwithstanding

the comparative universality of this intestinal organism, may be regarded as having some significance by reason of the absence of this bacillus from oysters which appeared to have been exposed to no such risk. 5th. In one case where the circumstances were especially suspicious, Eberth's typhoid bacillus was found in the mingled body and liquor of the oyster.

We stand, therefore, as regards the application of the science of bacteriology to the subject under discussion much in the same position as when my predecessor, Sir George Buchanan, arrived in 1882 at certain conclusions with respect to the researches of chemistry in connexion with samples of water contaminated with the specific infection of enteric fever; and paraphrasing what he then wrote concerning the chemist, I may say as the outcome of this inquiry as to the culture of oysters:—The bacteriologist can, in brief, tell us of impurity and hazard—often, indeed, of the precise nature of specific hazard—but not of purity and safety. For information about these we must go, with the aid of what the bacteriologist has been able to teach us, in search of the conditions surrounding and affecting the culture and storage of oysters along our coasts.*

When the oyster trade of Great Grimsby came under suspicion in connexion with the cholera prevalence of 1893, it was stated that, if there were any truth in the alleged risk, the resulting mischief would have been on a far wider scale than was actually the case. I ventured at that time to point out that in order to enable a given sample of oysters to convey the infection of any specific disease such as those which are here in question, it would be necessary that the shell cavity or body of the mollusc should retain some portion of the sewage—often in a state of great dilution—to which it had been exposed; that such portion of sewage should actually contain the specific infection; that this specific infection should not be destroyed by antecedent cooking or otherwise; and that the oyster or oysters should be consumed by some susceptible person. And I indicated that the co-existence, at one and the same time, of all these conditions was not likely to be of frequent occurrence.

Every skilled observer whose investigations have gone to show that certain oysters have served as the medium for conveying disease to man, has admitted that the risk is by no means a great one; several speak of such occurrences as distinctly rare; and certain observations which have been recently made, have afforded further data in explanation of this comparative rarity. Some have suggested that oysters previously contaminated with sewage may be able to free themselves from pathogenic organisms and their products by a natural process of cleansing, as a result

* Sir George (then Dr.) Buchanan wrote:—"The chemist can, in brief, tell us of impurity and hazard, but not of purity and safety. For information about these we must go, with the aid of what the chemist has been able to teach us, in search of the conditions surrounding water sources and affecting water services." Report of the Medical Officer of the Local Government Board for 1881. (C.—3337.—I.) 1882.

of being placed for a time in beds or ponds, the waters of which are free from such contamination.* Then again, the process of phagocytosis, in which certain microbes are assimilated within the body by living tissue cells, is stated to be one of exceptional activity in the oyster. And, lastly, we have learnt that though the contents of the oyster shell, and even the body of the oyster, may exhibit the specific organisms which are identified with such diseases as cholera and enteric fever, these organisms have no tendency to multiply within the oyster; and that, on the contrary, the cholera vibrio tends soon to lose its physiological properties. Under such circumstances, the frequent occurrence of disease, as the result of eating oysters, could hardly be anticipated. But the mere fact that occurrences of this sort are somewhat exceptional, can in no way justify the retention of those conditions by means of which these occurrences are now known to be brought about.

The French Académie de Médecine, on the Report of the Special Commission which they appointed, and to which reference has already been made, passed the following resolution:—"The Académie de Médecine, being convinced that the consumption of oysters which have been kept in a laying ('parc'), the water of which is polluted, may cause gastro-intestinal disturbances, and even typhoid fever with its serious complications, expresses the opinion that the properly constituted authority should superintend the management of the oyster layings along the coast, as also the importation of foreign oysters; and demands that oysters derived from localities known to be contaminated shall be deposited, for a period of eight days† before their sale, at some point along the coast which is washed by pure sea water."

It would further appear from Dr. Chantemesse's paper that France does not stand alone in the demand that this article of food shall, as regards its cultivation and means of storage, be placed under some control; but that the Government of the United States of America have had the subject under consideration in connexion with the "State Fish and Game Commission."

In view of the main facts which have been set out in this report it might perhaps be imagined that our English oyster fisheries compare unfavourably, in point of risk of sewage contamination, with those of foreign nations, from whose shores there is a considerable importation into this country. The

* See, for example, the Report for 1895, on the Lancashire Sea Fisheries Laboratory, Liverpool, by Professor W. A. Herdman, D.Sc., F.R.S., p. 61.

† Reference to Appendix No. III., will show that Dr. Chantemesse originally recommended a period of several weeks (quelques semaines). This longer period is in accord with the observations which Dr. Klein records, in this report, as to the behaviour of the typhoid bacillus in relation to the oyster.

Professor W. A. Herdman, D.Sc., F.R.S., in his Report for 1895, on the Lancashire Sea Fisheries Laboratory, Liverpool, gives evidence in the same direction. He writes: "In the case of the oysters grown in water infected with the *Bacillus typhosus*, it was found that there was no apparent increase of the organisms, but that they could still be identified in cultures taken from the water of the pallial cavity and rectum 14 days after infection."

evidence, so far as it goes, does not support any such view. Not only are some of our principal oyster layings, beds, and ponds altogether above suspicion in this respect, but their produce has, deservedly, the highest reputation. On the other hand, it is only necessary to read the papers of Dr. Chantemesse and of Mons. Joannes Chatin, appended to this volume, to learn that, as regards layings in the Mediterranean and on the coast of Brittany, conditions obtain which are fully as objectionable as those at certain points along our own coast; and, quite apart from the circumstances attaching to the particular laying with which the Connecticut outbreak, investigated by Professor Conn, was identified, there is definite evidence that the oyster fisheries across the Atlantic also call for supervision in this respect. I may add that I have personal knowledge of conditions of even greater gravity attaching to oyster fisheries elsewhere than in the countries specified. It is only within recent years that the need for protecting oyster fisheries against sewage pollution has forced itself on the attention of those who have responsibility for protecting the public health; and just as nations attach an importance to this consideration, beyond any that is concerned with mere commercial interests, so do they not hesitate to indicate without reserve their own shortcomings and the need for their amendment. In this respect we may claim companionship amongst some of the leading nations of the world.

The investigations which are recorded in this report were instituted with the sole desire of ascertaining whether, and how far, the oyster culture along our coast is associated with conditions which may at times involve danger to the public health; but, incidentally, the facts go to indicate that where such conditions do exist the remedy is, as a rule, a comparatively simple one.

I have only to add that, when other molluscs than oysters are used for human consumption in much the same way as oysters are, that which applies to oyster culture applies also to them; and in this connexion I would call attention to that part of Dr. Bulstrode's report which deals with other edible molluscs.

I have the honour to be,

Sir,

Your obedient Servant,

R. THORNE THORNE.

October, 1896.

APPENDIX No. 1.

PART I.

REPORT on an INQUIRY into the CONDITIONS under which OYSTERS, and certain other EDIBLE MOLLUSCS are cultivated and stored along the Coast of ENGLAND and WALES; by DR. H. TIMBRELL BULSTRODE.

INTRODUCTORY.

The inquiry to which this report relates was ordered by the Local Government Board, in view of a strong suspicion that oysters might have had to do with certain cases of cholera which occurred during the outbreak of that disease in this country in 1893; and the necessity for such an inquiry was further indicated in reference to official representations which were made to the Board during April 1894, respecting the conditions under which oysters were stored in readiness for market near a watering-place on the English littoral. The occurrence, too, in the autumn of 1894, of a limited outburst of enteric fever at the Wesleyan University, Middletown, Connecticut, U.S.A., in which the evidence pointed strongly to certain oysters, fattened in an estuary near to the outfall of a specifically infected drain, as having been the agents by which the disease was conveyed, attracted considerable attention in this country, and there followed much discussion of the subject in the leading English medical journals.

Although it is but recently that public attention has been prominently drawn to oysters as possible agents in disseminating enteric fever, the suspicion that these molluscs have at times been instrumental in causing disease and illness has existed for very many years. As an instance of this it may be of interest to relate that there appeared in the "Weekly Dispatch" of Sunday, August 18th, 1839, and of Sunday, August 25th, of the same year, the following paragraphs:—

1. "Weekly Dispatch," Sunday, August 18th, 1839.

" It is very important to avoid shell-fish at this season of the year, unless taken cooked. Nothing is more likely to become the immediate exciting cause of diarrhoea than oysters so early in the season."

2. "Weekly Dispatch," Sunday, August 25th, 1839.

"We cautioned the public, last week, against eating raw oysters. The necessity of that caution may be gathered from an account, in the 'Globe' of yesterday evening, of an inquest held on Thursday, at Ratcliffe Cross, before Mr. Baker, on the body of a butcher named Jolly. He had eaten some oysters, while labouring under a bowel complaint, on Sunday last. About five he was seized with violent cramps, his skin turned blue and shrivelled up, his nails became black, and he vomited much. He expired at eleven at night. Mr. Coward, the surgeon, said he had no doubt this was a case of malignant spasmodic cholera. A medical friend, who was quite conversant with the disease, had seen the deceased, and that gentleman's opinion coincide with his own. He

had ascertained from a leading physician that several cases had occurred at the west end of the town. Verdict: 'Died by the visitation of God.'"

It would be superfluous to refer here to all the reports and rumours which, in times past, have caused a certain amount of suspicion to be attached to oysters as the occasional disseminators of disease, but as a matter of historical interest it may be narrated that at the time of the 1849 visitation of this country by cholera, an outbreak of this disease occurred at Bridgwater and Taunton, which was considered to have been due to the consumption of some apparently decomposing oysters which had been condemned as unfit for food, but which were nevertheless given to certain school children in the district. All those, it was stated, who consumed the oysters were attacked, and several died. Dr. Brittan, of the General Board of Health, was sent down to investigate the outbreak, and a reference to it will be found, by Sir B. W. Richardson, in the "British and Foreign Medical Chirurgical Review" for 1853.

Again, in 1876, it was alleged that an epidemic of typhoid fever which occurred in Douglas, Isle of Man, was due to the consumption of oysters during their spawning season.

In 1880, Sir Charles Cameron, now Medical Officer of Health for Dublin City, read before the British Medical Association, assembled at Cambridge, a paper on the possible relation of typhoid fever to the consumption of specifically polluted oysters, in which he dealt with the risks of sewage contamination to which oysters laid down in Dublin Bay were in his view liable; and in 1889 it appears that cases of enteric fever in Dublin were regarded as possibly having had their origin from the ingestion of oysters.

Scattered throughout the medical journals may be found references, as a rule brief, to attacks of gastritis following the eating of oysters,* but, save in quite recent times, medical literature does not afford much information as regards the question of a possible relation between cholera or typhoid fever and the consumption of oysters.

Demand for the present inquiry did not, however, rest solely upon the data above referred to. The distrust which recent rumours had aroused in the mind of the public had had the effect of a temporary paralysis of the oyster trade, and very severe loss had been inflicted upon oyster merchants and their employés, so great, indeed, that representations on the subject were made by those interested in the oyster industry to the Board of Trade.

It was considered, therefore, that alike in the interests of a large national industry and of the public health, an inquiry and report was called for respecting the conditions under which oysters were planted or were stored along our coasts. Inquiry in this sense was accordingly instituted, and the opportunity was utilised for noting also in a number of different localities the circumstances under which certain other molluscs, as, for instance, mussels and cockles, are cultivated or are collected for market.

EXTENT OF THE OYSTER INDUSTRY.

In the first place it will be well, before dealing with the immediate subject of this report, to furnish some figures showing the extent of the industry concerned.

* As early in this century as 1821 there occurred an outbreak of gastro-enteritis at Dunkirk, which was reported to have been due to the ingestion of oysters procured from the coast of Normandy, "London Medical Repository," 1820, vol. 13.

In 1894 there were landed on the English and Welsh coasts by English dredgers, 27,747,000 oysters, valued at 84,271*l.*; the average price being per 100, 6*s.* 1*d.*, and per 1,000, 3*l.* 0*s.* 10*d.* These were delivered on the several coasts as follows :—

—	Oysters.	Value.
East coast - - - - -	16,833,000	£58,300
South coast - - - - -	4,251,000	11,186
West coast - - - - -	6,663,000	14,785
	27,747,000	£84,271

The number landed on each coast during the several months of the year are shown by the following returns :—

EAST COAST.

Month.	Oysters.	Value.
		£
January - - - - -	2,006,000	7,600
February - - - - -	1,812,000	6,676
March - - - - -	1,632,000	5,418
April - - - - -	1,267,000	4,423
May - - - - -	1,263,000	3,314
June - - - - -	964,000	2,211
July - - - - -	618,000	1,589
August - - - - -	1,189,000	3,626
September - - - - -	1,435,000	4,209
October - - - - -	1,594,000	5,715
November - - - - -	1,398,000	5,137
December - - - - -	1,655,000	8,382
	16,833,000	£58,300

SOUTH COAST.

Month.	Oysters.	Value.
		£
January - - - - -	158,000	527
February - - - - -	230,000	695
March - - - - -	300,000	837
April - - - - -	297,000	1,122
May - - - - -	287,000	976
June - - - - -	68,000	151
July - - - - -	102,000	245
August - - - - -	184,000	448
September - - - - -	659,000	1,536
October - - - - -	642,000	1,452
November - - - - -	635,000	1,373
December - - - - -	689,000	1,824
	4,251,000	£11,186

WEST COAST.

Month.	Oysters.	Value.
		£
January - - - -	125,000	310
February - - - -	175,000	475
March - - - -	299,000	583
April - - - -	204,000	505
May - - - -	546,000	1,207
June - - - -	736,000	1,586
July - - - -	974,000	2,133
August - - - -	1,297,000	2,835
September - - - -	1,030,000	2,309
October - - - -	711,000	1,418
November - - - -	393,000	983
December - - - -	173,000	441
	6,663,000	£14,785

TOTAL OF ALL COASTS.

Month.	Oysters.	Value.
		£
January - - - -	2,289,000	8,437
February - - - -	2,217,000	7,846
March - - - -	2,231,000	6,838
April - - - -	1,768,000	6,050
May - - - -	2,096,000	5,497
June - - - -	1,768,000	3,948
July - - - -	1,694,000	3,967
August - - - -	2,670,000	6,909
September - - - -	3,124,000	8,054
October - - - -	2,947,000	8,585
November - - - -	2,426,000	7,493
December - - - -	2,517,000	10,647
	27,747,000	£84,271

STATEMENT in detail showing the TOTAL QUANTITY and VALUE of OYSTERS returned as LANDED by our own DREDGEMEN on the ENGLISH and WELSH COASTS, together with the AVERAGE PRICE of the same in each of the Years 1892, 1893, and 1894:—

1892.	1893.	1894.	1892.	1893.	1894.	1892.	1893.	1894.
Oysters.			Value.			Average Price.		
No.	No.	No.	£	£	£	Per 100.	Per 100.	Per 100.
36,893,000	32,455,000	27,747,000	113,884	99,475	84,271	£ s. d. 0 6 2	£ s. d. 0 6 1½	£ s. d. 0 6 1

These figures relate exclusively to oysters landed by English boats employed in the home industry, and they afford no indication of the enormous trade done at the present time in imported oysters from other countries.

It will be obvious, however, from the figures which have been given, and it will perhaps become more patent later on when the several oyster layings have been described, that this industry, which directly and indirectly employs a very large number of persons as dredgers, packers, sellers, &c., is one of considerable magnitude and national importance.*

LEGAL PROVISIONS RELATIVE TO OYSTER FISHERIES.

For the purposes of this report it is needless to trace the development of the legal enactments which at the present time regulate the oyster fisheries of England and Wales, but it is desirable that a general idea should be conveyed as to the restrictions under which the industry is at the present time carried on.

The legal provisions which relate to oysters are for the most part contained in the following Acts, and to them, those seeking for more detailed information than is herein contained, must be referred:—†

The Sea Fisheries Act, 1868.

The Sea Fisheries Act, 1875.

The Fisheries (Oyster, Crab, and Lobster) Act, 1877.

The Sea Fisheries Act, 1883.

The Sea Fisheries Regulation Act, 1888.

The Sea Fisheries (Shell-fish) Regulation Act, 1894.

In addition to these general Acts, there are numerous local Acts and Charters conferring rights and powers as regards oyster and mussel fisheries upon Corporations and Companies.

Some of these local Acts are framed under the provisions of the general Acts referred to, but in many instances the local Acts and Charters are of much more ancient date. As an instance of an ancient Charter may be mentioned that possessed by the Corporation of Colchester. The fishing in the River Colne has, it is affirmed, "from time immemorial" belonged to the Corporation of the Borough of Colchester, and their first Charter in regard to it was granted in the first year of the reign of Richard I. (1180). The Corporation of Rochester, too, have, in the words of their Act under date of 1729, for "time out of mind" enjoyed the privilege of controlling the fishing in the River Medway. The Whitstable Company, which in 1793 obtained an Act of Parliament incorporating the Company of Free Fishers and Dredgers of Whitstable, may also be cited.

As regards local Acts of a comparatively recent date, but which were nevertheless passed before the general Acts chronicled above, the River Roach Oyster Fishery Act, 1866, may be given as an example.

In the *Sea Fisheries Act*, 1868, it is Part III. which has reference to oysters, and the most important provision therein contained is the

* It may, too, be borne in mind, that this industry not only provides a livelihood for a large population scattered over the English and Welsh littoral, but that it indirectly, as has been fully recognised in the attitude of the French Government towards the oyster industry of that country, helps to maintain a seafaring class whose value for the purposes of naval defence can hardly be overrated.

† The student of the law regulating oyster fisheries prior to the year 1876 will also derive much assistance from a perusal of the evidence given before the Select Committee on Oyster Fisheries, 1876, by Mr. T. H. (now Lord) Farrer, at that time Permanent Secretary of the Board of Trade,

power conferred upon the Board of Trade of making foreshore grants by means of Orders—of which there are two kinds, known respectively as “Several” and “Regulating”—to be confirmed by Parliament, for the purpose of oyster or mussel fisheries. This provision may be regarded as a good example of what has been termed “promotive” legislation.*

In this Act are set forth the steps to be taken to obtain an Order, and the conditions which are imposed upon the grantees. Briefly stated, it is necessary, before a grant can be procured, to satisfy the Board of Trade at a public local inquiry that the grant, if conceded, will be for the benefit of the public at large. These grants are made for not more than 60 years, and at any time they may be determined by the Board of Trade if, after local public inquiry, this central authority is satisfied that the cultivation or regulation of the concession has been neglected. An historical instance of such determination is that in regard of the Herne Bay Oyster Company, which Company was brought under the provisions of this Act by means of another to be presently referred to. A “Several,” or what may be termed an “Exclusive” Order, confers upon the grantee the exclusive control of the oysters on the ground in question. It also precludes, subject to the ground being properly marked out, persons other than the grantee or his agents from fishing over the prescribed area in such a way as to disturb the oysters, from dredging for ballast, and from depositing rubbish within the limits of the concession.

A “Regulating” Order confers the power to carry into operation the restrictions or regulations imposed by the Order, to levy tolls for the expenses thereby entailed, and to provide for the deposit and propagation of oysters within the limits of the fishery.

As instances of “Several” Orders now in force may be quoted those relating to Tollesbury and Mersea, and to Paglesham; while in the matter of “Regulating” Orders reference may be made to those of Swansea and Falmouth.

The 1868 Act also confirms the Convention of 1867 between France and England which applies to extra-territorial waters in the Channel between a line drawn from North Foreland to Dunkirk, and a line drawn from Land’s End to Ushant, and which provides, among other things, that no fishing for oysters shall take place in such waters from June 16th to August 31st inclusive. The Convention, although confirmed by this Act of 1868, was not ratified by France, and has consequently never come fully into operation. It was intended to supersede an earlier Convention (entered into in 1839 and confirmed by the Sea Fisheries Act, 1843), which applied to almost the same area, and under which a close time for oysters was fixed between April 30th and September 1st. This close time is still nominally in force to a partial extent, but by an agreement between the two Powers an arrangement is made only to enforce the shorter close time specified in the Convention of 1867.

The Sea Fisheries Act, 1875, was an amending Act, and although its terms were general, its effect was more particularly that of transferring to the Board of Trade the jurisdiction over the Herne Bay Oyster Fishery previously exercised by the Home Office.

The Fisheries (Oyster, Crab, and Lobster) Act, 1877, was passed to carry into effect some of the recommendations made by the Select Committee on Oyster Fisheries in 1876. This Act prohibits the sale of any oysters known at the passing of the Act in the oyster trade as

* The Relations of the State with Fishermen and Fisheries, by C. E. Fryer. [Prize essays issued in connexion with the Great International Fisheries Exhibition.]

"deep-sea oysters," between June 16th and August 4th, and also of any description of oysters other than deep-sea oysters between May 14th and August 4th. It, however, provides that it shall not be an offence under the Act if the oysters were taken within the waters of some foreign state,* or were preserved in tins or otherwise cured, or were intended for the purpose of oyster cultivation within certain prescribed limits. The Act also confers the important power upon the Board of Trade, when application is made to that authority, to temporarily prohibit or restrict dredging for oysters on certain banks. This prohibition may not exceed one year, but may be renewed. By this same Act a reduction is made on the somewhat prohibitive cost of obtaining an Order under the Sea Fisheries Act, 1868. It provides in regard of areas of less than 5 acres, where the grant required is for a period not more than 21 years, that under certain circumstances the Order may be confirmed by Her Majesty in Council instead of by Parliament.

The Sea Fisheries Act, 1883, prohibits the fishing for oysters, or the carriage of any oyster dredge, within any seas, and during the time within which oyster fishing is prohibited by law, or by any Convention, Treaty, or Arrangement to which the Act may eventually apply; and it also gives power to Sea Fishery officers to board boats with a view to detecting any contravention of these provisions.

The Sea Fisheries Act, 1888, is the Act which in large part at least governs both oyster and other sea fisheries within territorial limits at the present time. By its enactments the creation of local fisheries committees is provided for, these committees having, within certain limits, the control of the coast fisheries of England and Wales. Power is conferred by the Act upon the Board of Trade to create fishery districts upon the application of a County or Borough Council, or in their default, upon the application of not less than twenty inhabitant ratepayers interested in sea fisheries; to define the limits of such districts; and to decide the constitution of the committees which shall govern them. In other words, the Act confers a large measure of local government upon fishery committees. These committees have power, with the approval of the Board of Trade, to frame byelaws governing the fishing of their district, and they may also define the limits within which oysters may be sold for purposes of cultivation during the close season fixed by the 1877 Act. Their byelaws may also prohibit or regulate the deposit or discharge of any solid or liquid substance detrimental to sea fish or sea-fishing, provided that any such byelaws shall not affect any right of a sanitary or other local authority to discharge sewage in pursuance of any power given by a general or local Act of Parliament, or by a Provisional Order confirmed by Parliament. Fishery officers may be appointed for enforcing the observance of the byelaws.

At the present time nearly the whole of the English and Welsh littoral has been mapped out under the provisions of this Act into sea fishery districts, and the local committees are at work in promoting the fisheries under their care. It is important to note here that the fisheries committees have the power to extend as regards their districts the season during which the sale of oysters is prohibited by the Act of 1877, but that they may not curtail it. Permanent extension of "close time" has in some instances been thus brought about.

The Sea Fisheries (Shell-fish) Regulation Act, 1894, is important as regards oysters and shell-fish generally; in fact it was a necessity for

* In regard to this exemption, see remarks on "close season."

the better preservation of oyster culch which very materially aided the passage of the Bill through Parliament. This Act considerably extends the power of local fisheries committees to make by-laws for the regulation, protection, and development of shell-fish fisheries, and it provides that the expression "shell-fish" shall, for the purposes referred to, include all kinds of molluscs and crustaceans.

THE "CLOSE SEASON" FOR OYSTERS.

It is a common belief, and one which is in large part acted upon by the more educated portion of the community, that during such months of the year as have not the letter "r" in their names, *i.e.*, May, June, July, and August, oysters are "out of season." The belief is, no doubt, founded upon the fact, that during the months in question oysters in our waters are either shedding their spawn, preparing to do so, or recovering from the effects of having done so. The times at which oysters reproduce their species vary considerably in different places and in different years, but an observance of the standard above referred to, with the inclusion of the month of September,* would, as a general rule, and, as regards at any rate the oysters in this country, cover the actual spating season. A consumer, however, of the more expensive native oysters runs little risk of being served with this class of oyster out of season; proprietors of oyster beds having reputations to lose will not be likely to despatch oysters from them in a state calculated to bring discredit upon the locality. The protection, however, which is afforded by law to the breeding oysters is much more limited in extent than is that represented by the letter "r" basis; though the law, in the restrictions which it places upon the sale of oysters during the breeding season, has regard to the question of preventing the destruction of the reproducing oyster and its offspring, and not to the tastes of the consumer. The law allows oysters to be sold at all times of the year, save the period embraced between May 14th and August 4th. Between these dates, native oysters from our own shores are precluded from being sold for food while a similar restriction obtains for what are known as "deep-sea" oysters between June 14th and August 4th. It may probably be accepted as true that during this interval but few oysters are consumed by the more educated classes; but by that class which may be referred to here as the less fastidious, and especially to that part of it addicted to the practice of sea-side trips of brief duration, the consumption of oysters during the summer months is large. It will be remembered that the close season as laid down by the Act of 1877 does not apply *inter alia* to oysters taken in the waters of a foreign state, and it would therefore seem that during this period such oysters as can be then directly imported may be freely sold for consumption. It would also appear from a decision given by Baron Pollock, when an appeal was made upon the matter to the Queen's Bench Division of the High Court, that oysters imported from abroad and laid down in British waters for a period even as long as four months do not come within the restrictions of the Act in question. The matter from a legal standpoint is apparently regarded as one of degree, and the restrictions would, it seems, undoubtedly apply to oysters imported quite young into this country and allowed to grow to maturity. However this may be, the outcome in practice is that there is no period of the year during which oysters, either native or foreign, are not largely consumed in this country.

* In a batch of oysters received by me from Falmouth on September 15th, 1896, I discovered some in the "black sick" condition.

It may be convenient at this stage, and prior to the discussion of the subject with which this report is particularly concerned, if a short description of the economy of the oyster be given.

A GENERAL REVIEW OF THE POSITION IN CLASSIFICATION, THE ANATOMY, AND THE PHYSIOLOGY OF THE OYSTER.

The oyster is a member of the sub-kingdom *Mollusca*. The *Mollusca* are divided for the purposes of classification into two great branches, the *Aglossa* or *Lamellibranchiata*, which are headless molluscs, and the *Glossophora*, which are furnished with heads and the accompanying lingual apparatus. It is among the *Lamellibranchiata* that the oyster is placed by naturalists, and in that group of the *Lamellibranchiata* known as the *Monomyaria*, characterised by having—in their adult stage at least—but one adductor muscle, as contrasted with the *Dimyaria*, which have two.*

Finally, the oyster belongs to the family *Ostreidae*, and the genus *Ostrea*, the specific name of the European oyster being *O. edulis*, the American oyster *O. virginiana*, and the Portuguese oyster *O. angulata*. The geographical distribution of *O. edulis* is a wide one, and extends “from Tränen, in Norway, close to the Arctic circle, to Gibraltar and certain parts of the Mediterranean, Holland, and North Germany, to Heligoland and the western shores of Sleswick and Jutland. It occurs in Iceland, but does not enter the Baltic.” (Molluscs and Brachiopods. Cooke, Shipley, and Reed.)

The two valves of the shell of the oyster are, in the larval condition, alike, equilateral and symmetrical, but in a mature oyster they become unlike, asymmetrical and slightly inequilateral. In the asymmetrical or mature condition the shells are distinguished from one another by the fact that one, the left, which is comparatively thick and irregular, is convex externally and concave internally, while the other, the right, which is smoother in appearance, is flat and thin. Although the left shell is almost constantly convex externally, and the right or upper one flat, there are at times considerable departures from this condition, as where, for instance, the shell has attached itself in the young state to some object the contour of which it tends to follow in its growth. In some cases the oysters are found in clusters, their shapes then being determined by their mutual pressure. The outer and inner surfaces of the oyster shell present considerable contrast in appearance. The outer, which is coloured, usually some tint of brown, but varying according to the locality in which it is bred, is marked very distinctly by a series of concentric projecting ridges running parallel with the margin, and representing the successive lines of growth of the shell. By means of these ridges the age of the oyster, or rather the number of periods of growth and of alternating periods of rest from growth, may to some extent be inferred. It is, however, to be noted that at times there may be more than one period of growth in a year, and that in more advanced life the shells increase for the most part by the deposition of nacreous substance on the interior. Roughly speaking, an oyster of 1 inch in width may be said to be about one year old, an oyster 2 inches wide, two years old, &c. In addition to the concentric ridges just referred to, there are other ridges or ribs radiating from the apex of the shell towards its periphery, and varying in prominence in different races of oysters.

Although the outer surface of the oyster shell is, when exposed for sale, as a rule clean and free from marine vegetation, this is by no means always the state in which it is dredged up from its bed. The shell, and more especially the convex one, may then be found covered with barnacles or, in “spatting” estuaries, with young oysters. There may, too, in many districts be often discovered over the surface of the shell the sandy tubes of the tube-inhabiting *Sabella*, a worm with branchiæ on its head, and known among the dredgers as “ross;” the inhabited tubes being termed “live ross,” the uninhabited “dead ross.” In some districts the shells may be almost

* In point of time the monomyarian bivalves seem to have appeared on the earth after the dimyarian. A few bivalves were discovered even in the Cambrian rocks, and in the Upper Silurian they become abundant. About 9,000 extinct and 5,000 living species were catalogued some years ago. (Outlines of Zoology. Thomson.)

covered with little red ascidians, popularly known as "poch," or, in some districts, as "berries." In other cases anemones or other marine animals may be detected; in fact, almost any of the fauna or flora of the locality which has a tendency to attach itself to shells, including seaweed several feet in length, may be found so attached. Professor Möbius counted as many as 221 distinct animals of various species on one oyster shell (Huxley). At times, and more especially in the case of deep-sea oysters, the lower shell may be found literally riddled with small holes, a condition produced by the operations of the *Cliona celata* (or Boring Sponge), and which renders the shell extremely friable.

Sometimes the shells of young oysters may be empty, the valves being joined at their hinges (a condition to which the name of "clock" is given), the oyster itself having perhaps become the prey of the whelk tingle (*Purpura lapillus*), which has left its traces in one of the valves by a clearly-bored hole caused by its boring tongue (*radula*). On the external surface of the left or lower shell, and near its apex, may be usually detected a rough, irregular patch, of varying size, indicating the primary point of attachment of the oyster to rock, shell, or other substance, and, in cases where the oyster has been bred in certain cultivated areas, there may be seen the cement by which it was attached to the cemented tile or a piece of the bark separated from the twigs to which it adhered.

The inner surface of the oyster shell presents, in European oysters at least, a white, smooth, iridescent appearance over almost the whole of its surface. Near the margin, however, as also in the neighbourhood of the hinge, there is a well-defined division, where the brown exterior is apparent; it and an intermediate calcareous layer being found exclusively here, whereas the inner (nacreous) layer is found all over the surface. In approximately the centre of each valve, but rather nearer its posterior than its anterior margin, is a somewhat kidney-shaped depression, technically known as the "muscular impression," and which represents the point of attachment of the powerful adductor muscle. There may also be observed, in some cases, a faint lineal depression, called the "pallial line," which marks the attachment of the muscular fibres of the mantle, but this line in the monomyarian bi-valves is liable to be interrupted and indistinct.

The above remarks with reference to the uniform pearly whiteness of the interior of the shell relate more particularly to the oyster of Northern Europe, and to those which have been cared for in estuaries or cultivated beds. In another class of oyster, as also in those which have lain upon certain muddy bottoms, patches of discoloration not unfrequently present themselves; in some cases these patches are due to the deposition of nacreous and partly translucent substance over mud or dirt which the oyster has been unable to expel; in other instances—and more particularly those cases where the discoloration has a lineal disposition—they are due to the boring of a certain worm (known as the *Leucodore*), and the filling of its burrows with mud or other opaque substances. I am informed by Mr. Rupert Vallentin, of Falmouth to whom I am indebted for much valuable assistance, that these appearances may be, to a large extent, rendered invisible by the deposition for a time of the cyster on a sandy bottom. In places, too, there may be observed on the interior of the shell opaque chalky patches, whose formation is said to be due to some disturbed condition of the mantle, and these deposits not infrequently roof over one or more cavities which, on examination, are found to contain water, enclosed, apparently, at some antecedent period in the life of the oyster. The shells of oysters vary considerably in different localities, and oysters obtained from one place and laid down in another tend after a time to take on the appearance of the oyster peculiar to that locality, a fact which is drawn attention to by Darwin in "Animals and Plants under Domestication."

In the Portuguese and American oyster the muscular impression is of a deep blue colour, and these oyster shells can therefore be readily distinguished from the North European form.

The shell itself consists chiefly of calcareous particles, which are held together by an organic secretion; and, by means of incineration on the one hand, and by steeping in acetic acid on the other, the inorganic or organic constituents of the shell may be separated. The animal substance, which is

termed *conchiolin*, disappears after a time in the dead shell, which is thus rendered more brittle and friable.

As will have been gathered from reference to the lower (attached) valve as the "left," and to the upper as the "right," the hinge side of the oyster is the dorsal surface, and the margin opposite the hinge the ventral. The anterior margin of the shell is usually rounded, while the posterior margin is straighter, and if the oyster be held with this anterior margin away from the observer and the hinge uppermost, the convex or lower valve will be on the left, the flat one on the right. Looking at the interior of the shell, it is to be remarked that the muscular impression is nearer the posterior than the anterior margin.

When the oyster is at rest or dead its valves gape slightly, a position due to the elasticity of a ligament which is wedged in, as it were, between the valves near their apices, and if an inspection can be made of the oyster while its valves are parted, the margins of the shell-forming organ, or mantle, may be detected extending to the edge of the shell. When, on the other hand, the oyster is alive and alarmed, as by being taken from the water, its valves close tightly, so that any water contained between them is prevented from escaping. The oyster is thus able to protect itself, and to travel for long distances out of water. The two valves are brought together by means of the powerful adductor muscle already referred to, and known in the oyster trade as the "heart." This muscle has to be divided in the process of opening the oyster, and the popular idea that this structure is the heart of the mollusc leads to the supposition that when the oyster is opened death immediately results. This, however, is not the case, and the true heart of the oyster may, under favourable circumstances, be observed pulsating for hours after the severance of the adductor muscle. The muscle, which probably corresponds to the posterior adductor of the dimyarian molluscs, consists of two parts, a more ligamentous portion and a more muscular portion, and these two parts are said by Von Ihering and Hoek to possess different functions, the ligamentous portion near the pericardial cavity having the function more particularly of normally keeping the valves closed, while the more muscular portion has the power of suddenly closing them on the approach of danger. The muscle keeps its relative position in the growing shells by means of the absorption of its more dorsal fibres and the deposition of fresh ones on the ventral side.

On opening an oyster by the division of the adductor muscle, in such a manner as not to disturb the other parts, and removing one or other of the valves, the soft part of the animal will be exposed to view, and the fleshy mass of the oyster will be seen to occupy nearly the whole of the shell cavity.

The animal itself is seen, on examination, to consist of what may be called a "trunk" proper, increasing in size from above (the hinge end) downwards, and including the viscera, the central circulatory system, and the adductor muscle. From this extend downwards, forwards and backwards, two lobes, known as the "mantle" lobes, one on each side of the "trunk." The external surface of each mantle-lobe adheres closely to the inner surface of that valve of the shell with which it is in apposition: the line of attachment, known as the "pallial line," being some little distance from the edge of each valve.

Each mantle-lobe has its free edges thickened out, and is furnished with a double row of sensory papillæ, which probably possess a tactile function. It is the membranous portion of the mantle which secretes, during life, the inner nacreous layer of the shell, while the thickened edge serves to secrete the outer layers, including the coloured foliaceous portion, and also the substance attaching the oyster to the rock or "culch," a function to be presently referred to. The two lobes of the mantle serve to enclose and protect the respiratory organs, or branchiæ, and to form a large cavity, known as the branchial chamber, in which these lie. The distal margins of the mantle-lobes are not united to one another except towards the dorsal surface, when they are joined both in front and behind.

More particular description of the oyster will probably best be effected by taking each system separately, and in describing the several parts, the oyster will be regarded as held with its dorsal margin uppermost.

The Respiratory Apparatus.—The branchiæ or gills (the "beard") are very important organs in the oyster, and some knowledge of their structure and

arrangement is necessary for an understanding, not only of the respiratory processes of this mollusc, but also of the mechanism of feeding, and, in *O. edulis* at least, of part of the reproductive process. They may be seen, on raising either lobe of the mantle, to have the appearance of a delicate membrane, finely striated in a direction at right angles to its length, and extending from near what will presently be described as the *oral palps* to near the anal orifice. There are two gills, each consisting of a pair of plates, each plate consisting of a pair of lamellæ, or rather of one lamella bent upon itself, and with connexions between its two parts. Each lamella consists of filaments also connected with one another. The outer lamella of the outer plate on each side is attached to the internal surface of the mantle-lobe of the same side for the greatest part of its length, while the lamellæ of the inner plates are attached to one another.

The general effect of this arrangement is to divide the cavity enclosed between the lobes of the mantle into two parts, separated by the lamellæ of the gills. These two parts are known as the *supra-branchial* and *infra-branchial* chambers. Each gill is attached, for a short distance, to the trunk of the oyster, but posteriorly it is separate from the trunk, and so leaves a larger and continuous *supra-branchial* chamber, here called a cloacal cavity, wherein, near its lower extremity, on the anterior surface of the adductor muscle, the genital and renal duct opens, and, on the posterior side, the rectum. The inner surfaces of the gill-plates, which form, as it were, the floor of the supra-branchial chamber, present the appearance of a series of pockets, owing to the connexions between the lamellæ. Water, of course, circulates round these lamellæ, and so between the transverse partitions connecting them, *i.e.*, into the pockets.

Each gill axis contains in its interior a blood vessel giving branches to each of the *branchial filaments*, which form a lamina. By means of the spaces known as "water pores," where the filaments are not fused with one another, the water in the infra-branchial cavity has access to that in the supra-branchial chamber. The surface of each branchial filament is ciliated, the cilia moving in such direction as to drive the water through the water-pores into the supra-branchial chamber.

The water thus swept from the infra into the supra branchial-chamber is replaced by fresh water passing in from below, and it is upon the maintenance of this stream that the aëration of the blood contained in the branchial filaments depends. In addition to driving the water through the branchiæ in the way just explained, the cilia also serve to convey the animal and vegetable organisms contained in the water, and caught on the surface of the gills, along to the labial palps, and thus into the mouth; in other words, the gills serve as a sort of filter, the water passing through them, leaving the animal and vegetable organisms it contains on the surface, to be passed on towards the mouth for the purpose of food.

Apart from the question of feeding, the main point to remember is, that during life there is a strong current of water passing in at the *infra-branchial* chamber, and passing out at the exhalent, or *supra-branchial* chamber, so that not only does this current purify the blood contained in the blood vessels permeating the branchiæ, and convey food to the surface of the gills for transmission to the mouth, but it also serves to carry away the waste products which pass from the kidneys and the anus, and, at certain seasons of the year, also the reproductive products, in a manner which will be presently referred to.

The Digestive System.—The digestive system of the oyster consists of an alimentary canal, and an out-growth of it known as the "gastric gland."

In front of the mouth are two structures much resembling the gills in appearance, and known as the "labial palps." The mouth opens into a short gullet, or "œsophagus," and this into a capacious stomach surrounded by the gastric gland; this is followed by a long and tortuous intestine, which ends in a rectum with anus.

The stomach is provided with a blind sac or *cæcum*, within which is usually lodged a long cylindrical body known as the hyaline or crystalline stylet.* The

* The hyaline or crystalline stylet has been only recently recognised in the oyster, and I am told, that in order to study it satisfactorily, it is necessary to examine the oyster quite fresh from its native habitat as the stylet shortly becomes absorbed.

function of this stylet does not appear to have been determined, but it is believed by Möbius to represent a reserve of food material.* After leaving the stomach, the intestinal canal pursues a very circuitous course, passing first down to and along the anterior edge of the adductor muscle, in the substance of that part of the trunk called by Hoek the "oral process," then, after turning sharply and running back parallel with and over itself, it makes a loop round the stomach, and passes along the posterior margin of the adductor muscle to end in the anus, which lies in the cloacal cavity, or termination of the supra-branchial chamber.

The gastric gland (often, without due reason, called a "liver") is a dark, olive-green mass, which lies beneath the ramifications of the generative and urinary organs, through which it is, as a rule, just visible as a dark patch. The substance of the gland envelopes the stomach, the œsophagus, and a considerable portion of the intestine. As to the exact functions of this gland little is known, but it secretes a fluid which is thought to assist the progress of digestion. This is the only gland connected with the intestinal tract of the oyster.

The oyster possesses no distinct lymphatic system; the soluble products of digestion pass into the general abdominal cavity, and thus into the larger veins.

The Nervous System.—The majority of the molluscs in this class are possessed of three pairs of nervous ganglia, but in the oyster where the foot is absent, there are but two pairs to be detected, *i.e.*, anterior and posterior. The anterior pair of ganglia, which are situated near the œsophagus or gullet, distribute nerves to the labial palps, to the anterior parts of the mantle, and to portions of the branchiæ; the posterior pair, which are situated between the anterior border of the adductor muscle and the oral process, supply the posterior parts of the mantle and the branchiæ, the organs of Bojanus, and the adductor muscle.

Special Senses.—The tentacles situated on the margin of the mantle are, as has already been pointed out, the representatives of tactile organs, but apart from these no other organs of special sense have ever been detected in the oyster, though there would seem to be some question as to whether the labial palps may not be able to exercise some selective sense in the matter of food,† and as to whether the oyster may not be sensitive to light.

The Circulatory System.—The heart of the oyster is situated in a pericardial cavity or space occupying a position between the upper or straight margin of the adductor muscle and the lower border of what has been called the trunk proper. The heart consists of three chambers, two auricles and a single ventricle, the auricles being situated on the oral or anterior side of the pericardial cavity, the ventricle on the posterior side. The walls of the auricles are thick and spongy, and they are easily to be distinguished from the ventricle by their browner colour. The ventricle itself is double in that part near the auricles, but at a point more distant the two halves unite; it communicates with the auricles by means of two short channels, and each auricle receives a vessel from the branchiæ of its side (Hoek). The blood, which is colourless, and contains numerous colourless corpuscles, is propelled by the contractions of the ventricle into the aorta, a large vessel which divides up into smaller trunks, the ramifications of which supply the soft parts of the mollusc with blood. No true capillaries exist in the oyster, but their places are to some extent supplied by a system of *lacunæ* and sinuses, which permeate the connective tissue, and which serve to conduct the blood into the venous system. After passing through the renal organs the blood traverses the gills or branchiæ, where it becomes aerated, and it finally returns from the gills of either side by a separate blood vessel to the auricle of the same side, where the circulatory processes above indicated recommence.

The Excretory System.—The function of excretion in the oyster is performed by the kidneys, or organs of Bojanus, our knowledge of which is due to the researches of Dr. P. P. Hoek.‡ As is the case with the generative organs, the

* Outlines of Zoology (Thomson). Mollusk and Brachiopods, by Cooke, Shipley, and Reed. (Macmillan & Co.)

† See "*Woodward's Mollusca*."

‡ Rapport sur les recherches concernant l'huître et l'ostréiculture.

organs of excretion do not, as in other Lamellibranchiata, form a compact mass, but consist of a number of long cæca, from which arise other cæca, the whole spreading out in the substance of the connective tissue existing between the epidermis of the trunk proper and the generative organs, and even into the mantle. The cæca finally open into a longitudinal cavity known as the urinary chamber, which chamber empties itself by means of a short canal, the ureter, into the urino-genital slit, the same aperture as that into which genital duct empties, and which is situated in the substance of the "oral process."

The Reproductive Process and the Larval Oyster.

The anatomy and physiology of the reproductive system of the oyster have been the subject of much labour and not a little controversy, but the researches of recent years have gone far to settle the vexed questions previously in dispute. It would seem to be now almost generally conceded—thanks in no small degree to the labours of Hoek and Möbius—that *O. edulis* is hermaphrodite, but that, as in most hermaphrodite animals, the two sexual elements are not ripe at the same time in the same individual, so that self-fertilisation is prevented.*

Anatomically the generative organs consist simply of paired glands, producing spermatozoa or ova as the case may be, and efferent ducts; accessory organs are absent. Each gland is made up of numerous canals, which tend at their distal extremities to anastomose with one another, and even with those of the opposite side. The ramifications of the tubular gland extend over the substance of the "liver" and intestine, and are separated from the surface of the body by a thin layer of connective tissue only, thus giving rise to the reticulated appearance of the trunk of the oyster, especially marked during the breeding season. The spermatozoa or ova are developed from cells lining the follicles inside the tube. The efferent duct on either side is situated in the substance of the "oral process," and opens, together with the nephridial duct, into a groove, the urino-genital slit, situated near the branchial nerve ganglion on the "oral process."

The spermatozoa of the North European oyster "when ripe" pass by means of the urino-genital aperture into the supra-branchial chamber, from which they escape into the surrounding water, with the exhalent current. Their future fate depends upon whether they are within a short period brought by currents within the sphere of operations of an oyster acting functionally as a female, or whether they are drifted in other directions. If they are drawn by inhalent currents into the sub-pallial cavity of another individual whose ova are ripe, and enter the urino-genital aperture, they traverse the genital duct and its larger branches, thus coming in contact with the ova; so that the impregnated ova are already far advanced in segmentation by the time they are discharged by the urino-genital aperture (Hoek). It is supposed that when the impregnated ova reach the posterior part of the supra-branchial or exhalent chamber, they, or a vast number of them at least, come within the sphere of influence of the inhalent current, along with which they pass into the infra-branchial chamber, where they may be seen bound together, as it were, into a viscid mass situated on the branchiæ. It is in this chamber that the eggs undergo a further process of development, and it is only when the embryo has reached a stage at which it is capable of maintaining an independent existence that it is ejected by the parent oyster into the surrounding water.

* In the other species of oysters (*e.g.*, the Portuguese and American) the sexes are separate, as they usually are in Lamellibranchiata.

When first the embryos take up their abode in the sub-pallial chamber of the oyster, they present the appearance of a whitish granular mass, bound together by a viscid fluid secreted from the branchiæ, and it is to this condition of the parent oyster to which the term "white-sick" is applied. Later on the tint becomes darker, and the mass bears a strong resemblance, both in appearance and to touch, to moistened slate pencil powder, the parent oyster when in this condition being said to be "black-sick." It was formerly believed that the "white-sick" and "black-sick" states of the oyster represented different sexual conditions, but subsequent observations demonstrated the fact that each condition was caused by a different phase of development of the larval oyster.

When the larval oysters are ejected by the parent—a process brought about by the sudden closure of the valves, and which gives rise to an appearance which was described by the late Frank Buckland as strongly resembling a puff of smoke from a steam-engine—each one pursues a vagrant existence for a short period, probably ranging from three or four days to a fortnight,* moving by means of a ciliated band or *velum* which is capable of being drawn in between the mantle lobes by means of muscular apparatus. At this stage the infant oyster may be drifted long distances from the place of its birth by tide, current, or wind, and carried far away from the beds upon which it was born. As with other larvæ, the risks of destruction by cold or by living enemies is enormous, and only a very small proportion of the larval oysters set free from the parent in the natural condition can survive to attain the fixed state, and reach maturity. The larvæ that so survive fix themselves to some hard, clean, substance, if such there be in the neighbourhood, and take up their abode there, not improbably for life. Fixation is effected by means of the secretion, from a protruded portion of the left lobe of the mantle, of a cement substance.† It will be remembered that it is the left valve of the shell which eventually becomes concave, namely, the lower one. When the larval oyster first attaches itself it has the appearance of a white glistening speck, not unlike a spot of candle grease, and it is this which, as evidence of a "fall of spat," is so anxiously watched for by the oyster farmer. "White-sickness" or "black-sickness," and even the presence of the larval oysters in the water, may occur in proper succession and yet no "fall of spat," as it is called, be observed. Owing, as above stated, to the extreme susceptibility of the larvæ in their freshly liberated state to variations of temperature, a cold night or cold rain, at such a time is sufficient to work great destruction. It is for this reason that attempts at artificial culture in this country are attended with great risk, and that artificial heating of ponds has been in some cases resorted to, in order to supply artificially the natural climatic conditions which obtain in certain other countries.

The breeding season of the oyster varies very materially in different latitudes and different years, but, as has been pointed out under the heading "Legal Provisions relative to Oyster Fisheries," it is probable that, in this country at least, actual spatting, in nearly all years, takes place from May to September inclusive.‡ The reproductive power of

* Huxley succeeded in keeping the young oyster alive in a bottle of sea-water for one week. See article on Oysters in *Encyclopædia Britannica* (ninth edition); also Lecture on Oysters and the Oyster Question, by Huxley, which was delivered at the Royal Institution, Friday, May 11, 1889, and published subsequently, with additions, in the *English Illustrated Magazine*.

† For some interesting observations in connexion with this subject, see paper by Mr. John A. Ryder in *Bulletin of United States Fish Commission*, Vol. II. (1882).

‡ See footnote on page 8.

the oyster seems to extend over a considerable portion of its natural existence, since some oysters may begin to breed even as early as in their first year of life; at any rate, in their second. Oysters of four or five years of age are the most prolific. In those of more advanced age the "liver" becomes hypertrophied and the reproductive organs atrophy. It seems, from the experiments of Hoek, that, among oysters examined by him, in a given season a greater number produced spermatozoa than produced ova.

The fecundity of the oyster is enormous, each spatting oyster of the N. European species giving rise, it is estimated, to about a million ova, while the American and Portuguese are more prolific still; but, as has been said, the number of larvæ which reach maturity is clearly but a small fraction of the total. Möbius calculated that in Europe, each oyster born into the world has but one chance in 1,145,000 of reaching maturity, and Brooks has endeavoured to show that, in the case of the Portuguese and American oysters, where the young are not protected by the parent in the same way, the chances are considerably less than this. The Portuguese and American oysters are uni-sexual, and their ova and spermatozoa respectively are carried by the exhalant currents into the water surrounding the oyster, so that the question of their loss or survival depends upon the two sexual elements being brought effectually into contact outside the parent. The loss of ova and spermatozoa must in this case be very large; as Brooks remarks, a little fish swimming along with open mouth might swallow thousands in a few mouthfuls, and the greater birth-rate of the American oyster is, he thinks, more than compensated for in the matter of survival by the shell with which the larval European oyster is provided.* Ryder discovered some 200 larval oysters in the stomach of an adult.

The fact that in the Portuguese and American oysters the sexual elements are set free from the parent before they are brought together, has enabled experiments to be made in artificial fecundation, which may not unlikely prove of much value in oyster culture.†

THE OYSTER INDUSTRY OF ENGLAND.

The oysters consumed in England may be divided broadly, for descriptive purposes into three categories:—

- (1.) Oysters born and bred in this country.
- (2.) Oysters introduced from abroad, and laid down for varying periods in our waters.
- (3.) Oysters imported from abroad and consumed without being relaid in this country.

I propose now to give a short account of each of these classes of oysters.

Oysters Born and Bred in this Country.

The English "native" oyster is still in quality the best the world produces, but the natural yield of the English beds has, for many years, been undergoing a marked decrease, and at the present time the natural

* Rearing oysters from artificially fertilised eggs, together with some notes on pond culture, &c. Bulletin U.S. Sub-commission, vol. 3, 1883.

† Artificial fecundation has been performed by Brooks and Ryder with American oysters, and by Bouchon Brandely and Lieut. Francis Winslow with Portuguese oysters.

produce, even with the aid which science has been able to afford, is not sufficient to furnish the home markets with a supply of "native" oysters at a price within the reach of persons of moderate means. The home-bred supply has, therefore, to be supplemented very materially by the importation of foreign oysters, a subject which will be more fully referred to later on. It is not necessary, and it would require a lengthy and perhaps unprofitable digression to discuss here the several causes which have been held to account for the diminution of the home-bred supply; the subject is one of considerable difficulty, as may be gathered from a perusal of the reports of two Commissions* appointed to consider the matter, the one in 1866 and the other in 1876. These two Commissions, after having heard evidence on the subject, enunciated several recommendations, which differed very materially in principle. In part the diminution may be apparent only. Thus the development of railways and of telegraphic communication has had the effect of diffusing oysters over inland districts, where before it was difficult, if not impossible, to obtain them fresh, and the facility of transmission has doubtless afforded opportunities for an appreciation of the oyster by a wider section of the community, and this in turn has resulted in a much increased demand.

Still, after due allowance has been made for this fact, there is no doubt but that the natural yield of our waters has, within recent years, very materially diminished. This diminution has been accounted for partly by the failure of the natural spat, partly by over-dredging, *i.e.*, it has been the result of unfavourable climatic conditions or want of proper management. What influence each of these factors has had in the different localities in bringing about the diminution in question it is beyond the province of this report to discuss.

The chief "spatting" estuaries of England are situated for the most part on the east coast, and in the counties of Suffolk, Kent, and Essex, especially the latter; and it is to the oysters of this region to which the term "Native" is more particularly, and, by some exclusively, applied.†

Although it is on the coast line above mentioned that the more important "spatting" grounds are situated, there are numerous other places in England and Wales where there are indigenous oysters. For instance, in and around the Solent are natural spatting grounds, as also in Poole Harbour, while further westward, at Falmouth and Truro, and in the Helford River, are rich natural beds. As, however, each of these places, in addition to others, will be referred to in detail in the part of this report devoted to the description of local fisheries, it will be superfluous to devote more space to them here. I shall therefore proceed at once to give a brief outline of the processes adopted in the estuaries of England, in the matter of oyster farming, and in making these observations, it will be convenient to start with the preparation of the ground for the reception of the spat, to which reference was made when describing the reproductive system of the oyster.

* Report of the Commissioners appointed to inquire into the Sea Fisheries of the United Kingdom (1866).

Report from the Select Committee on Oyster Fisheries (1876).

† Mr. Frank Buckland in his evidence before the Select Committee of the House of Commons, in 1876, defined a "native" as being a thoroughbred oyster taken in the estuary of the Thames, landward of a line drawn from Harwich on the north to Margate on the south. Q. 265. As a matter of fact, a "native," even in the more restricted use of the term, is simply an oyster which has been bred in or near the Thames estuary, and it has in practice no essential relation to the origin of the seed oyster. In its broad sense the term "native" is applied with a prefix to most of the best oyster localities in the country.

In order that as much of the *larvæ* of the parent oyster may be saved as possible, it is necessary, among other considerations, that when the time for the fixation of the larval oyster arrives, it shall find a clean hard bottom upon which to take up its abode. An estuary which possesses a clean firm bed is provided with a most important factor towards successful oyster cultivation, and where this feature does not obtain, it behoves the hand of man to supplement, as far as possible, the deficiency. If the larval oyster falls upon soft, muddy ground, it is lost to the oyster merchant, but if, on the other hand, it falls upon a clean surface, the chances of its survival are enormously enhanced. In order to bring about this desirable condition of affairs where it does not exist naturally, clean hard substances are laid down in the estuaries just prior to the liberation of the infant oysters from their parents. These substances may consist of oyster shells, dried and bleached on the river banks during the winter months, or of cockle shells, &c. In addition to these, numerous other contrivances, called "collectors," are made use of, more especially abroad, such, for instance, as tiles covered with a specially prepared cement consisting of lime, sea-water, and sand in variable proportions, which allows of the easy chipping-off of the attached mollusc; twigs, upon the bark of which the spat fixes itself; wooden splines, &c. &c.*

The essential feature, however, is that all, or any, of these contrivances shall be clean, so that the infant oyster shall adhere thereto, and in order as far as possible to secure this cleanliness, the oyster shells† ("culch"), or whatever form of collector is used, must not be laid down until as near to the time of the larval oyster's liberation as possible. Upon the exercise of proper judgment in the deposition of the "culch" a great deal depends: if it is deposited too early, the material becomes covered with a slimy deposit which is fatal to the adhesion of the spat; if, on the other hand, it is deposited too late, a large number of the infant oysters may be lost.‡ It is for this reason that, when the spatting season approaches, every indication of the appearance of the "black-sick" condition has to be carefully watched for, and when it is manifest the "culch" is spread out with all possible speed.

The spatting season varies in different localities, and more especially in different years; in warm summers, oysters have been observed "white-sick" at the end of May, and "black-sick" a fortnight later; while, on the other hand, oysters have been known to spat as late as October or November; but in this latter case the probability of the spat surviving is remote.

During, and for some time after, the "fall of spat," the grounds are, as a general rule, allowed to remain at rest. The spat which adheres to the "culch" laid down is left attached to it until the summer of the following year, when, in the more northern fisheries at least, it is separated by means of an instrument known as a "cultack," and either laid in a definite area of the ground or placed in the wintering pits, to be shortly referred to. The separated oysters are known at this period as "brood."

* In America scallop and mussel shells are sometimes used.

† The term "culch," or "cultch," is by some applied exclusively to oyster shells, by others it is used indifferently to denote almost any kind of material laid down for the collection of spat.

‡ As an instance of the preference of the *larvæ* for a clean surface, it may be related, that when cemented tiles are used it will often be found that where a slimy deposit has taken place on the upper surface but few oysters will be found, while the under surface, which has remained free from deposit, will be found thickly covered with young oysters.

In respect to the procedure during the autumn months, there is some variation in, what may be termed, the northern and southern estuaries of this country. In many of the more northern estuaries, *i.e.*, in those of Essex, the oyster stock is, during the autumn, dredged up from the river, carefully cleansed and culled over, and deposited, during the winter and early spring, in pits excavated in the marshes alongside the estuaries; the different sized oysters being deposited in separate pits.

These pits or ponds, some of the best of which are represented in the accompanying photographs,* are essentially excavations in the marshes of some 12 to 18 inches in depth, their size and depth varying in different localities, and they are, usually, covered with water only at high spring-tides. As a rule, however, the ponds are fed by a canal or backwater, so that the water in them may be changed more frequently than at spring-tides; and in order to allow the entrance of fresh water the ponds are furnished with sluices, by which the water can be admitted at will, while a pipe, fitted with a plug, at the level of the bottom of the pond, serves to let out the stale water when necessary. In many cases the ponds are rendered more complete by lining the sides with wood, while the bottom is covered with cockle shells, gravel, or chalk, the spaces between the several ponds being bricked over so as to present a better appearance and to facilitate operations. In some cases periwinkles are placed in the water of the ponds, so as to keep it clear of a green slimy weed which tends to grow therein. Certain of the ponds are used at times for the storage of marketable oysters, and these are not infrequently of rather better construction than those used for wintering, the bottom and sides being of cement or some other hard substance. It is said that this provision tends to aid the oyster intended for market in ridding itself of any mud, &c., and to generally improve its appearance when opened for food. We here have, in fact, an approach to a method practised in some parts of France, and which is known as *dégorgement*.

The oysters placed in the wintering pits are able to withstand a considerable degree of cold, and they will survive even when the pits themselves are thickly covered with ice. If left in the tide way, the oysters, during the winter, are not unlikely to be killed by frost, when, during the prevalence of low spring-tides they may be quite exposed along the foreshore. Again, they are liable to suffer from the effects of "freshets," more especially when, after wintry weather, the melting of the snow in the uplands brings down much snow-water over the layings. Apart from the adverse influence of fresh cold water upon the oysters, floods may act harmfully by bringing down with them a large quantity of suspended mineral matter, which, entering the oyster, interferes with its vital processes. The market pits, in addition to protecting the oysters, obviously provide easy access to them during stormy weather.

The oysters are taken out from the wintering pits about March or April, and replaced in the estuaries to grow and "spat." Experience has taught that retention in the pits is prejudicial to both these processes; indeed it seems that the reproductive organs of the oyster are extremely susceptible to changed conditions. When taken out from the pits the oysters are distributed, in many instances at least, according to their size, in different parts of the grounds. It is found, as a general rule, that a good growing area is not a good fattening area, and that a good fattening area may be prejudicial to spatting processes. This being so, on the majority of grounds a certain portion is set aside for the purpose of fattening, and oysters which are to be ready for market in the ensuing

* Photographs Nos. 1, 2, and 3 were taken by me in the course of my inspection, while No. 4 was very kindly presented to me by the owner of extensive oyster fisheries in the locality.

summer and autumn are, when taken from the wintering pits, placed on the areas in question or moved there at a subsequent date. It is from these *fattening beds* that the oysters required for market are, as a rule, taken during the summer and early autumn, though they may often be stored for a limited time, so as to be more accessible, in the market ponds.

The amount of labour to be bestowed upon an oyster ground varies enormously in different localities, accordingly as the ground is naturally "clean" or the reverse. In some cases deposits of mud, or of sand, or the luxuriant growth of sea-weed, render constant attention necessary to prevent the ground from being choked; and for this reason the grounds have to be frequently dredged and the stock culled over and cleaned. In some instances, especially in the spring, after deposit has taken place during the winter on oysters left on the beds, these cleaning operations are much assisted by a process of "harrowing," by which the deposited mud, sand, &c. are disturbed and carried away by the tide. These "barrows" have teeth some three or four inches in length, with turned-up ends; in fact, they bear a strong resemblance to the harrows used by farmers on the land.

Again, the ground may be subject to invasion by some of the numerous direct enemies to the oyster. Some grounds abound in starfish (*Uraster rubens*) or sun-stars (*Solaster papposa*), animals which by the eversion of their stomachs, are able to kill and digest the soft parts of the oyster *in situ*; on other beds, again, the whelk-tingle (*Purpura lapillus*) flourishes, and it is this mollusc which is so fatal an enemy to the young oyster by means of its "boring-tongue" with which it penetrates the oyster's shell. Amongst other direct enemies of the oyster must be mentioned crabs, which are formidable antagonists even of the largest oysters, and ground fish, such as skate, which are responsible for an enormous destruction of the smaller oysters.

In addition to these so-called direct enemies are others that may be regarded as indirect, inasmuch as they compete with the oyster for the food of the district, or by their presence tend to accumulate mud and sand, which in turn serve to choke the oyster. As an example of the former class may be mentioned other kinds of shell-fish, such as mussels, cockles, &c., which, by filtering through their gills large quantities of water, deprive it of the *diatoms* and *infusoria* it contains, and thus indirectly rob the oyster. Barnacles, or Acorn shells (*Balanus balanoides*), again, not only obtain the food of the oyster, but by attaching themselves to the oyster shells, reduce the surface for adhesion of the oyster spat. Mussels also act as indirect enemies by means of the *byssus*, which they secrete from their glands, and which tends to bind together stones and shells, &c., and thus to collect mud and to smother the oysters.

Where wintering pits are not used, as for instance in the south and west of England, the operations connected with the beds consist in constant dredging to keep the grounds clean, the separation of the oysters from one another, and the deposition of the various sized oysters in their appropriate areas in the estuaries.

The dredge usually used varies in weight according to the depth of the water and the nature of the ground for which it is to be used; in dredging for "deep-sea" oysters a much stronger and heavier implement is required than in estuaries, the estuary dredges being about 16 lbs. in weight, the "deep-sea" as much as 70 lbs. The dredge consists of a triangular iron framework with a ring for the attachment of the rope at its apex, while towards the base is fixed what may be termed a bag, the mouth of which is kept open by the base bar of the frame, and which is known as the "bit" or "knife." That part of the bag which, in the act of dredging, is



No. 1.—Photograph to show Wintering and Storage Ponds, on the banks of the River Roach in Essex. The River Roach, from which the oysters are dredged up, is seen in the distance.



No. 2.—Photograph to show Wintering Pits, Storage Pits, and Packing House on the banks of Paglesham Pool, Essex. (See Map No. 2.)



No. 3.—Photograph to show Storage or Market Pond at Paglesham Pool ; and dredgermen sorting oysters for dispatch to market.



No. 4.—Photograph to show Market Pond as seen in No. 3; the water has been let out, and the oysters are packed up in bags ready for dispatch.

brought into contact with the ground is often composed of stouter material than that of which the upper part is made; in deep-sea work the ground portion is constructed of iron rings, and the upper of netting, but in estuary work, where there is danger of damaging the young oyster brood, hide or some other soft substance is made use of. The sailing dredgers work, as a rule, two dredges, but the steam dredgers, of which the number is increasing, carry several. In sailing vessels the success attending the operations depends in no small degree upon the wind. It is said that in the steam dredgers the dredges do not "bear" so well as in sailing boats, but against this drawback is the fact that steamboats can carry more dredges and work in most states of wind and weather. When the dredges are full it is hauled up and emptied out on deck, the contents often consisting of a heterogeneous collection of oysters of all sizes, besides numerous representatives of the marine fauna and flora of the district. In some places starfish, sunfish, whelks, mussels, or crabs abound; in others the dredge may contain little else than oysters and oyster shells of various sizes. However this may be, the contents are carefully culled over by the aid of an instrument known as a cultack, a weapon much like a large oyster knife. The oysters are picked out and separated according to size, and young oysters attached to "culch" are, if large enough, separated therefrom. The "enemies" of the oysters are, on well regulated grounds, destroyed, and the remains of the dredges' contents are thrown back into the estuary by what are called "culch" boards.*

The operations referred to in the outline given above vary somewhat in different estuaries, but it is sufficient to convey an idea of the general principles governing the procedures. It must of course be borne in mind that the remarks apply more especially to appropriated grounds, and not to the mouths of estuaries, as on the Kent and Essex flats, where dredging can be carried on promiscuously by private dredgers. In these parts all spat, brood, or oysters obtained are disposed of to the best advantage by the dredgers, either to Companies, such as the Whitstable Company, or to private oyster merchants having grounds of their own. There is also much purchase of oyster brood, &c. between the several Companies. The Whitstable Company, for instance, at times buys very largely from those in Essex, while again, much "brood," is purchased by certain Companies from abroad, especially from France, as also from the West of England.

Artificial Oyster Breeding in England.

A description of the home-bred oyster industry of England would be incomplete without some reference to artificial oyster culture, by which is here meant the breeding of oysters in inclosed spaces or ponds from parent oysters deposited therein for spatting purposes.†

The principle underlying artificial oyster culture is, in the first instance at least, the reception and retention for a while of the larval oyster in a confined space. As has been previously pointed out, the risk to which the larval oysters are liable in a state of nature are great and

* In America "tongs" and "nippers" are used in addition to dredges.

† This industry is one of considerable antiquity, and dates back to about a century B.C., when one Sergius Orata cultivated oysters in Lake Fusaro, in Italy, and it is said that a form of oyster culture was practised in China even antecedent to this date.

multitudinous, and artificial culture aims at reducing these risks to a minimum by protecting the larvæ from destruction, whether by climatic influences or by the numerous other enemies to which reference has already been made.

In the more southerly countries of Europe oyster culture, in the sense indicated, has been attended with very marked success, and attempts in this country have been, in the main, but imitations of continental methods.

Very large sums of money have been expended in England in attempts at artificial oyster culture, a fact which is borne witness to by the numerous breeding ponds still in existence. The most noteworthy of these attempts was made at the Reculvers, near Herne Bay, on the north coast of Kent, and at Hayling Island, in Hampshire. At this latter place are, perhaps, some of the best constructed ponds in existence, and they were erected at a considerable outlay by the South of England Oyster Company. There are also breeding ponds on the banks of the Medina and Newtown estuaries, as also in the Beaulieu River, at Brading, and in the estuary of the Orwell. In all these ponds the methods adopted have been identical in principle, *i.e.*, oysters about to spat have been introduced to furnish the larval oyster, and "collectors" of various kinds have been laid down for the capture of the spat. The "collectors" used have been, in the main, cemented tiles such as are common in France, or fascines of twigs, as used in Italy; but oyster shells, cockle shells, hurdles, and in fact all manner of contrivances, have from time to time had their share of attention. Further than this, attempts have been made to artificially aërate and, even in recent instances, to warm the water contained in the breeding ponds.

In principle, breeding ponds consist of excavations of different depths, furnished with a sluice for the admission of fresh sea-water, as occasion may require, and an escape valve at the bottom for cleansing purposes. The bottoms of these ponds are generally covered with gravel, cockle shells, or the shells of oysters, while at intervals about the pond may be placed "collectors" of various kinds. Breeding ponds require careful management during the spatting period, and narratives are not unknown of disaster wrought by workmen changing the water in the ponds during the critical period of the floating spat, or letting in cold water at undesirable times.

Unfortunately, it cannot be said that the attempts at artificial oyster culture which have been made in this country have, generally speaking, been attended with much success, although I am informed that during quite recent years successful falls of spat have been procured in breeding ponds in the south of England. In numerous instances the floating spat has been detected in the ponds, but no fixation of it has taken place, while in other cases attempts to rear the spat have failed.

It may be that what are termed good spatting years are, owing to the climatic conditions of this country, separated from one another by such wide intervals as to practically ensure attempts at artificial culture, in the sense above indicated, becoming financial failures. At any rate it may, I think, be said that hitherto science has been unable to so supplement or assist nature's processes in this country as to bring about successful results such as have attended operations in France, Italy, and other countries. In fact, experience in this direction seems to indicate that quite young oysters, of about the size of sixpence, can be imported from France into this country and reared with a greater certainty of a substantial return than is to be obtained from artificial breeding.

Oysters introduced from Abroad and Laid Down in the Waters of our Estuaries.

During the months of March, April, and May, in each year, large consignments of oysters from abroad, more especially from France and America, are imported into this country for the purpose of being relaid in the waters of our estuaries. The oysters imported from France are of all sizes, from that of a sixpence to that of marketable oysters; those from America are as a rule only of the larger sizes. The quite young oysters from France are imported with a view of their being reared for the English market, and much labour is expended upon their culture. These oysters—as, indeed, all oysters coming from a more southern climate than our own—are found to be extremely susceptible to the influences of an English winter, and in the case of those oysters which are marketable, an endeavour is made to get rid of them, as far as possible, before the onset of frosty weather. In some cases, however, where this is not practicable, the delicate French and Portuguese oysters are sent in the winter to warmer layings in the south and west of England, as, for instance, to Hayling Island and Falmouth, and it may be here remarked that both of the oyster Companies which have their head-quarters at Whitstable, have winter layings in the south of England. As will be seen under the description of the local fisheries, a very large number of the layings in this country are devoted to the planting of foreign oysters. The larger oysters imported in March, April, and May, are laid down in our estuaries, partly, perhaps, for the purposes of convenient storage, but in the main for growth or fattening. It is found that American, French, and Portuguese* oysters, laid down in our estuaries in the spring, undergo a remarkable improvement in quality during the summer months, and that their marketable value is thereby considerably enhanced; in the case of some other foreign oysters, such, for instance, as the Dutch, relaying has not proved so successful. The foreign oysters laid down in the spring come into market, if they are required, shortly after their arrival on our shores, but it is preferred that they should sojourn in English waters for at least several weeks of summer in order that their condition may be materially improved.

The quite young oysters imported into this country from France, are placed for a time in—what are called in France—ambulances, *i.e.*, cases with bottoms of wire-netting and wooden sides, which are raised off the bottom of the estuary by supports. During the summer these oysters are in some cases sent to other and northern grounds, where it is found that they grow well, and in the autumn of the year they are returned again to more southern layings. This process is repeated until the oysters are ready for market.

The winter of 1895, unfortunately, afforded a lamentable instance of the effect of the English climate upon oysters brought from a more southern latitude, and the mortality among the foreign oysters wintering in the south of England was enormous; and this, too, in spite of every effort made to save them. There are few more depressing sights than to witness the culling over of oysters after a winter of exceptionable severity, the separation of the living from the dead revealing the loss which has been sustained.

* Relaid American and Portuguese oysters are either sold as such, or by the more grandiloquent terms of “Anglo-American” or “Anglo-Portuguese.”

Oysters Imported direct from Abroad and Consumed without being Relaid in our Waters.

As has been pointed out, the majority of foreign oysters introduced into this country during the months of March, April, and May, are intended for the purposes of relaying in English waters. During other months of the year, however, foreign consignments are intended, in the main, for immediate consumption. The source of these oysters from foreign countries is the same as that of those imported to be relaid, but large quantities are also imported from Holland,* Belgium, and other countries. As has been stated under the heading of "Legal Provisions relative to Oyster Fisheries," the close season does not apply to oysters taken in the waters of a foreign State, so that directly-imported oysters may legally be consumed all the year round. I am informed by Mr. Mussun, of Liverpool, with whom I conferred at Cleethorpes, that the chief ports for the introduction of American oysters into this country are Liverpool and Southampton, and for North Sea oysters, Grimsby and Brightlingsea. The same gentleman also informed me that American oysters which are intended for shipment are taken up from the beds on the Wednesday, and are shipped on the following Friday; they arrive at Liverpool on the following Saturday week, or thereabouts, and they are immediately distributed about the country. In addition to oysters imported from abroad, it must be remembered that a very considerable number are imported into England from the Scotch and Irish beds. These beds are not treated of in this present report, inasmuch as their positions, from a public health standpoint, are matters which concern primarily the Local Government Boards of Scotland and Ireland.

The American oysters† are extremely hardy, and are able to resist the cold of our climate, a fact probably due to their birth in a colder region. American oysters appear to be imported at all times of the year, save during the months of June, July, August, and September.

Their non-delivery here during these months is partly due to the fact that they are at that time spawning, partly to the high temperature usually then prevalent, and which renders the long journey unsafe. As regards American oysters, some idea of the extent of their importation may be gathered from the following table, published in the "Fish Trades Gazette," and taken from the Sixth Annual Report of the Inspectors of Sea Fisheries of England and Wales.

1891.	Liverpool.	At other Ports.	Totals.
	Barrels.‡	Barrels.	Barrels.
January - - - -	6,769	545	7,314
February - - - -	7,366	555	7,921
March - - - -	16,455	733	17,188
April - - - -	26,375	4,855	31,230
May - - - -	14,992	160	15,152
October - - - -	2,724	—	2,724
November - - - -	11,674	233	11,907
December - - - -	9,207	732	9,939
	95,562	7,813	103,375

* In 1893, 4,942,630 were imported into England from Holland (13th Annual Report of Fishery Board for Scotland).

† The American oysters imported into this country are known as "Blue points" from Brookham Bay, off the south coast of Long Island; as "East Rivers" from the East River, and as "Sounds" from Staten Island.

‡ The number of oysters contained in a barrel depends upon their size.

The Packing of Oysters prior to Transit.

In the transport for long distances of oysters from place to place, whether for purposes of relaying or for delivery at market, considerable care has to be exercised in packing, inasmuch as upon this depends in no small degree the mortality during the journey. When it is remembered that oysters imported from America may be out of water fully a fortnight, it is obvious that they must be placed under circumstances enabling them to conserve as long as possible the water enclosed between their valves when they were taken from the oyster bed. The usual practice is to pack the oysters with their convex, or deep shells, downwards, in order that as much of the oyster "liquor" as possible may be retained. Oysters in large quantities are as a rule transported, when they are conveyed long distances, either in barrels, hampers, or boxes; if, on the other hand, they are to travel but a short distance, sacks or bags are often used. In the case of the American oysters transport is effected in barrels closely packed, whereas for Portuguese or French oysters either boxes or hampers are common. In the case of the quite young French oyster brood, to which reference has been made, small boxes divided by a partition are common.

The packing and transport of oysters raises an interesting incidental question, and that is, the length of time oysters will live out of water. The answer to this question must necessarily depend in no small degree upon the conditions under which the oyster is placed on removal from the water. For instance, an oyster placed upon its flat shell would survive for a shorter time, *ceteris paribus*, than one placed upon its convex shell; and, again, an oyster suspended or placed with its hinge in a dependent position would, not improbably, succumb sooner than one placed with its ventral edge downwards; that is to say, if the edges of the shell were sound. The time of year, too, during which oysters are withheld from water will obviously have an important bearing upon the question under discussion; extremes of temperature in either direction being prejudicial to their survival. Some oysters, notably American, will live for a very long time out of water; but obviously, in the consideration of the general question, a distinct line must be drawn between the time which it is desirable that oysters intended to be placed directly on the market should be out of water and the time which it is possible to keep oysters alive which are intended for relaying purposes. Clearly, the latter class would be often unfit for consumption until after sojourn again in a suitable water.*

The Storage of Oysters in Shops.

When the oysters arrive at the retail establishment, the methods of treatment seem to vary not a little, but it is necessary to bear in mind

* (a.) It is recorded by Professor A. E. Verrill, in the Bulletin of the United States Fish Commission for 1886, that on December 10th, 1884, a cluster of oysters was exposed out of water in a shop window, and on February 25th, 1885, some of the largest oysters remained alive. It was observed that the oysters still alive were hanging with the front edge (? ventral) of the shell downwards and the hinge upwards, *i.e.*, in such a position as would be most advantageous for the retention of water in the gill cavity. The oysters in question were observed to possess very perfect shells, the margins of which fitted very closely.

(b.) It was stated by Mr. H. G. Austin, before a Select Committee of the House of Commons, in 1876, that oysters, if properly packed, would remain alive during the cooler months of the year for *six weeks*, but this statement was traversed by other witnesses. There seems, however, little doubt that oysters, under certain conditions, will live for fully this time.

that the modern development of telegraphic, railway, and steamboat communication render it easy to procure fresh supplies at frequent intervals from the beds, and thus to render storage in the sense here indicated in large part unnecessary. In many instances the oysters are placed in tubs or other receptacles filled with water, to which salt and oatmeal have been added, the water being changed from time to time, and by this means the oysters tend to become what in America is known as "plumped" or "water-swollen." It is obvious that if the water in which the oysters are thus temporarily stored is derived from a polluted source, danger might accrue.

There is, however, another aspect from which the storage of oysters, after the above fashion, in water must be viewed, and that is the possibility that oysters to which a specifically polluted muddy deposit adheres, may, when added to a receptacle containing water and other oysters, contaminate that water, and thus, perhaps, the other oysters undergoing storage there.

The cleanliness of the shells of oysters sent to market varies not a little, a fact which may easily be verified by an inspection of the oysters piled up and exposed for sale in an oyster shop. In some cases, more especially so with the more smooth-shelled oysters, the shells will be seen to be quite clean; but in the case of the irregularly-shaped Portuguese oysters, there may often be detected deposits of mud of unknown composition in the depressions of the shell.

The storage of oysters in water is, however, by no means a universal method. The oysters are often kept for long periods in a cool place covered simply with damp seaweed or with a damp cloth; in fact there is no doubt that at the present time oysters in the majority of instances are kept only for a short period in the shops, and that fresh supplies are obtained at frequent intervals from the layings or beds. It may be well here to insist on the fact that, although stale oysters may at times give rise to attacks of gastric disturbances in those consuming them, that this question has no relation to typhoid fever. To contract typhoid fever from the consumption of oysters, it is essential that the oyster be specifically contaminated with the particulate cause of typhoid fever. Still the oyster merchants and shopmen should in the interests of the public health, as also in their own defence, supply nothing but fresh oysters to their customers, and oysters stored in shops only for a brief period should be kept under the most wholesome conditions obtainable.

In England, as doubtless most people are aware, the oyster is presented to the consumer upon its flat shell, that is to say, in opening the oyster the adductor muscle (erroneously called the "heart") is severed on the convex side of the oyster. Oysters opened and served up in this manner certainly present an attractive and cleanly appearance, but in this process of opening a considerable quantity of the oyster liquor is lost. In France, on the contrary, the oyster is served up on its convex or deep shell, together with much of the liquid which was contained between the valves before opening. In England, oysters are, as a general rule, opened by introducing the oyster opener between the valves at the side of the oyster; in France, opening is effected from the "heel" or hinge, by the separation of the internal ligament.

Again, in the opening of oysters at oyster bars in England, there is a considerable disparity of practice. In some cases the oyster is opened and straightway upon its flat shell placed before the consumer; in other instances the oyster, after opening, is dipped together with its flat shell into a receptacle containing water. By this means, not only is

the oyster deprived of much of its "liquor," but the water in the basin or tub referred to tends to become more and more dirtied, in direct proportion to the number of oysters with their shells dipped therein. If it is necessary to wash the mollusc after opening, probably the best method would be to place it momentarily beneath a tap of running water. In some cases an ablution of this kind is necessary, inasmuch as in the opening of the oyster a little grit, perhaps, introduced by the knife, may be found.

It would seem, however, that the dipping of oysters into receptacles of water is passing gradually into desuetude, and in the best oyster bars of the Metropolis the oysters are placed upon the plate of the customer directly they are opened.

SCOPE OF INQUIRY.

THE object of this inquiry has been to ascertain the extent to which, in one and another locality of this country, oysters, planted in the tide-way or stored upon the foreshore, are as matter of practice, subjected to conditions potentially dangerous in the sense of rendering them liable, habitually or occasionally, to fouling by sewage; and, as a consequence, to contamination by those micro-organic causes of infectious disease, which are themselves apt to become mingled with sewage, and so with tidal water to which sewage has access.

The micro-organisms which have been especially held in view as possibly gaining access along with sewage to oysters, are Koch's cholera vibrio and the bacillus of enteric fever. Of these, and in this country, the enteric fever bacillus no doubt frequently, the cholera vibrio only rarely or exceptionally, gains access to sewage. But at the date of commencement of this inquiry little was with certainty known of the abilities of these microbes to continue living for any considerable length of time in sewage; and similarly, no trustworthy evidence was then available as to whether either, if it obtained lodgment within the oyster, could for long maintain its life in the presence of the physiological activities of that mollusc.

It was thus seen that, in view of existing knowledge on these matters, the presence of sewage upon oyster beds remote from the point at which it had been discharged into tidal water by no means necessarily implied the presence also of dangerous elements of the above sort; as also that detection of these microbes in the water of oyster ponds or on the external surfaces of the oyster, afforded no sufficient proof that the mollusc inside the shell had as a consequence been rendered deleterious.

But not less was it evident that definite information on these matters was essential for a proper understanding of the questions at issue. Wherefore Dr. Klein, who, in pursuance of the Board's Auxiliary Scientific Investigations, had already commenced to make study of the behaviour of the typhoid bacillus and Koch's cholera vibrio in sewage and in potable water, was instructed to extend his observations of these microbes to the effects on them of water of different degrees of salinity, and to study also their abilities to maintain themselves within the economy of the oyster itself.

Meanwhile, pending report by Dr. Klein on that section of the subject entrusted to him for study, it was determined that inquiry into the conditions under which the oyster industry is conducted on our coasts, should be proceeded with. But in the circumstances it was judged premature to engage at each of a number of different localities in an extended series of float-experiments as to the set, under different conditions of wind and weather, of tidal currents, with reference to the distribution and range of sewage discharged into rivers and estuaries. So, too, chemical and bacteriological testing, on definite plan, and on any large scale, of water from oyster grounds and oyster ponds seemed at this stage altogether out of question. All that could be attempted with promise of useful and practical result appeared to be survey on broad and general lines of the physical circumstances of the several oyster industries of England and Wales, with special observation in each instance of the topographical relations of the oyster grounds (inclusive of layings, fattening beds, and storage ponds) and the outlets of local sewers and drains. To investigation in this sense of oyster industries I received instructions to address myself.

AN ACCOUNT of the OYSTER "BEDS," "LAYINGS," and "PONDS," on the ENGLISH and WELSH LITTORAL.

As has been already pointed out, the chief centre of the English oyster industry is situated on the coast and in the estuaries of Essex and Kent; and it may be said in general terms that a study of the conditions under which the industry is there carried on, might be taken as a fair index of the conditions obtaining in other parts of the English and Welsh littoral. Still, it became apparent, as the inquiry to which this report relates progressed, that the only satisfactory or, perhaps, it should be called, equitable method of procedure, was to visit all the localities on the coast of England and Wales where the oyster industry is known to be prosecuted. As far, therefore, as it has been found possible to ascertain the whereabouts of such localities, this has now been done.

Some difficulty was at first experienced in discovering where the smaller layings were located, as there is no central office or offices either in London or in the provinces where full information as regards oyster layings, &c. can be procured, *i.e.*, there is no obligation on the part of an oyster merchant to register any beds, layings, or ponds. I have, however, received very material assistance both at the outset and during the progress of this inquiry from the Board of Trade, and more particularly from Mr. C. E. Fryer, one of Her Majesty's Inspectors of Fisheries, and to this gentleman I wish here to acknowledge my indebtedness.* From this source, and from the inquiries which I have made in the course of my inspection, it has, I think, been possible to ascertain the whereabouts of all the more important oyster fisheries, and most of the smaller ones from which oysters are supplied to the public.

It has been necessary in the majority of cases to pay more than one, and in some cases several visits to certain localities in order to view them under as many aspects as it seemed desirable. For instance, in some places it was found that only at low water of spring tides could an inspection of the oyster layings and of the sewer outlets in the vicinity be made, and consequently a second visit was necessitated on this account.

The description of the separate oyster layings, &c. here given commences with the north side of the Thames at Leigh and Southend, and continues in a northerly direction up the east coast of England; then down the west coast and along the south, until it finally terminates on the south side of the Thames. Maps have been supplied in numerous instances, and, although they do not profess to be drawn accurately to scale, they will serve to indicate the approximate relation of oyster "layings," &c. to sewer and drain outfalls, and to otherwise assist the reader in following the descriptions given of each locality to which they relate.

The localities visited in the course of this inquiry are arranged below in groups according to counties.

Essex -	{	Southend.
		Leigh.
		The Rivers Crouch and Roach.
		The Blackwater.
		The Colne.
		Hamford Water.

* I have also derived much aid from the Reports of the Inspectors of Sea Fisheries issued annually by the Board of Trade.

Suffolk	-	-	-	{	The Orwell. The Deben. Orford River. Butley Creek.
Norfolk	-	-	-	{	Blakeney. Wells. Burnham. Lynn.
Lincolnshire	-	-	-	{	Cleethorpes. Grimsby.
Northumberland	-	-	-	-	Budle Bay.
Cumberland	-	-	-	{	Skinburness. Whitehaven.
Lancashire	-	-	-	-	Fleetwood.
Carnarvon	}	-	-	{	Beaumaris.
Anglesey	}	-	-	{	Bangor.
					Menai Bridge.
Pembrokeshire	-	-	-	{	River Daucleddau. Milford Haven. Tenby.
Glamorganshire	-	-	-	-	The Mumbles.
Cornwall	-	-	-	{	Helford River. Falmouth. Truro. Fowey. Saltash.
Devonshire	-	-	-	{	Dartmouth. Brixham. Torquay. The Teign. The Exe.
Dorset	-	-	-	{	Wyke Regis. Poole.
Hampshire (including the Isle of Wight).				{	Beaulieu River. Hamble River. Newtown River. Medina River. Wootton Creek. Emsworth Creek. Hayling Island.
Sussex	-	-	-	{	Bosham. Shoreham. Southwick.
Kent	-	-	-	{	Whitstable. Faversham. The Swale. The Medway.

At the places visited in the course of my survey, I received every assistance, and was afforded every facility for inspection, by those engaged in the oyster industry, and in all instances the officers of the sanitary authorities, to whom I applied for information with regard to details

of drainage and the positions of sewer and drain outlets, gave me all the information in their power. It is impossible to mention all these gentlemen by name, but I would take this opportunity of acknowledging the valuable and cordial assistance I received at their hands. I also wish to acknowledge with gratitude the facilities afforded me by the Librarians of the Zoological and Linnean Societies for kindly allowing me to consult works of reference at the libraries of these Societies.

The oyster merchants are naturally desirous to do all that can be done to restore the confidence of the public, and I believe they will hail with satisfaction any measures likely to bring about this state of affairs. There can, I think, be little doubt to anyone conversant with all the facts of the case that, as a class, the oyster merchants have suffered somewhat unjustly, and that merchants whose layings, &c. have been so situated as not to be exposed to danger from sewage pollution, have had to suffer equally with those whose default in this respect tended to accentuate the fear of evils which actually attached to the consumption of oysters from layings, oyster pits, &c., situated in positions which obviously courted danger.

PART 2.

INSPECTION OF LOCAL OYSTER INDUSTRIES.

SOUTHEND OYSTER LAYINGS. (Map, No. 1.)

There are at Southend two "layings," for oysters which are despatched direct to market, the one to the west and the other to the east of the pier. The "laying" to the west is used at the present time for deep-sea oysters only, owing, it appears, to the fact that the oyster merchant to whom both layings belong recognises fully the contamination to which oysters laid down in this situation are exposed from Southend sewage; in fact, during an interview I had with him at Southend, he expressed his opinion that the bed in question was perhaps more exposed to sewage than any other in England. He apparently considers, however, that deep-sea oysters may be laid down in this position, inasmuch as they are mainly used, after having been cooked, for the purpose of oyster sauce.

The approximate position of the oyster-laying westward of the pier to which the above remarks relate will be seen by reference to the accompanying map, where it will be apparent that the oysters are laid down between two sewage outfalls.

With a view to ascertaining to what extent oysters laid down in this position on the foreshore are exposed to the risks of sewage contamination, I, in company with the Medical Officer of Health for Southend, visited the pier outfall in a rowing boat, and we had little difficulty in following some of the solid faecal matter passing out of the sewer as it floated up past the watch-boat near to the oysters; moreover, for a large area between the two western sewer outfalls the sea-bottom was covered with paper which had evidently been deposited there from the sewage. It would seem, therefore, that the oysters placed where indicated must at times be exposed to sewage escaping by one or other of these outfalls, both on the flowing and ebbing of the tide. With regard to the view of the owner, that the oysters laid down here are used only for the purposes of sauce, it appears to me difficult to guarantee that the oysters

after leaving the beds shall be so used, or even, if all sold ostensibly for sauce, that some shall not be eaten raw.*

To the east of the pier on the Southchurch Hall foreshore a larger area than on the west is used for oyster planting; the oysters here laid down are intended, I was informed, for local consumption. They comprise French, Portuguese, Blue Point, East River, and North Sea oysters. A large sewer to the east of the pier, ends some three-quarters of a mile landward of these layings, and empties itself in the position indicated upon the map, at a point 600 feet from the shore. So far as this outfall is concerned, the risks of pollution which are incurred by the beds on this side of the pier may be practically remote; but as regards the outfalls west of the pier, it is by no means unlikely that at certain states of the wind and tide these easterly beds are not secure from chances of sewage pollution.

Taking now a general view of the Southend sewers, it will be seen that there are three main outfalls which have already been referred to, two to the west and one to the east of the pier. In addition to these, however, there are storm outfalls from which at times sewage issues. Of these, one is situated to the east of the pier near the Parade Post Office, and another, just beneath the pier at the point where the solid masonry terminates. There are, too, eastward of the gasworks, and, I believe, outside the borough boundary, other small sewer outfalls. With reference to the storm outfalls, it may be related that on July 5th I noticed sewage discharging from that near the Parade Post Office; and on the following day, when in company with Dr. Waters, the Medical Officer of Health of Southend, complaint was made to us of the nuisance which arose from the discharge of sewage from the Parade outfall during periods of heavy rain; and similarly, when near the pier storm outfall, complaints of the same character were also made. It should be stated that the complaints in both instances were quite gratuitous, and not due to any leading questions on the part of the Medical Officer of Health or myself. In addition to the storm outfalls referred to, there are, beneath the lavatory w.c.'s in the pier pavilion, two soil pipes from the w.c.'s emptying themselves directly upon the shore. These closets are used by visitors to the Southend pier, who, on some excursion days, number, I am told, many thousands.

It is necessary to refer to these pier closets for reasons which will now be apparent.

* Beyond this there arises the question whether, even if the oysters are used solely for sauce, the treatment to which they are subjected during their preparation for sauce is such as to lead necessarily to the destruction of any pathogenic organisms contained in them. To assist me in the solution of this point, I have consulted some standard works on cookery, and from Mrs. Beeton's book (new edition), which, I understand, is largely used by those engaged in cooking, it appears that in the preparation of oyster sauce, although the oysters are ordered to be just "raised to boiling point," it is a matter for special injunction that the sauce should not be allowed to boil. It seems, too, that the oyster liquor which is separated from the oyster during the early processes of preparation, but subsequently added to the sauce, is not raised to boiling point.

This question naturally raises a further one, namely, the power of resistance of the Eberth-Gaffky and comma-bacillus to heat. In regard to the former it appears from Janowsky's experiments that a temperature of 55° C., *i.e.*, one far below boiling point, if continued for 10 minutes, renders sterile cultivations of these bacilli, but that if continued for only five minutes, sterilisation cannot be relied upon. Klein too, states that the typhoid bacillus never survives a temperature of 60° C. for five minutes. It is not, however, clear from these experiments what effect is produced by momentarily raising the temperature to boiling point. With regard to the comma-bacillus the above remarks would seem also to have application, since heating cultures containing these bacilli to 60° C. for five minutes, effectually sterilises them.

MAP TO INDICATE POSITION OF OYSTER LAYINGS AT SOUTHEND AND IN HADLEIGH RAY.

Map No 1.



Scale of One Inch to One Statute Mile = $\frac{1}{63360}$

WYMAN AND SONS LTD LITH LONDON 7623 1195.

- = Oyster Layings.
- X = Sewer Outfalls.
- X = Storm Overflows.

Several of the oyster merchants in Southend possess floating boxes, in which oysters not required for immediate sale are from time to time deposited. These boxes are moored a short distance south of the pier pavilion; one of them at the time of my visit being 36 yards from the nearest lavatory closet drain pipe, at the foot of which pipe I discovered solid fœcal matter. It would seem, therefore, that there might be danger of the oysters in this position becoming fouled by sewage from the pier. There are, in addition, other oyster boxes along the beach towards Southchurch in which "native" oysters are stored for short intervals during the season. In fact, on one of my visits to Southend, I discovered some of these boxes moored in a position which I should regard as ominously near one of the smaller outfalls in the neighbourhood of the gasworks. Oysters are, I was informed, occasionally stored in this position, being placed there for a few hours "just for a drink." There is obviously need for much more careful selection of site in the mooring of oyster boxes.

The Leigh Oyster Layings. (Map, No. 1.)

The oyster "layings" near Leigh, a village a short distance westward of Southend, are situated in what is known as Hadleigh Ray, over that portion of the water way coloured green on the map.

There are two separate oyster merchants concerned with these layings, but as the grounds are contiguous it is probably unnecessary for the purposes of this report to differentiate. In the case of the more westerly ground foreign oysters are, when ready and required for market, taken up, packed in baskets on the watch-boat, and brought to Leigh station for despatch by rail.

The other oyster layings extend along Hadleigh Ray eastward of those just described. Here the oysters required for market are, at low tide, raked up in heaps, forked into baskets, and washed in the tideway. They are then taken in a small boat to alongside the watch-boat, where they are counted, again washed, and then packed in barrels holding 900 oysters each. After heading up, the barrels are rowed to Leigh and despatched to their destination.

In regard to these layings in Hadleigh Ray, it would seem that any risks of sewage pollution to which they may possibly be liable would occur on the flood, and in connexion with the western outfall sewers of Southend. To the westward of Leigh the district is quite unpopulated, save at South Benfleet, about 4 miles above this laying, where the drainage from some 15 houses finds its way into Benfleet Creek.

THE OYSTER FISHERIES OF THE CROUCH AND ROACH RIVERS. (Map, No. 2.)

These two rivers, like others on the east coast of Essex, are in no small degree natural oyster grounds, and the operations of persons who own or hire the right of oyster fishery in them consist in the main of aiding and supplementing nature's processes. It is matter of interest that the oysters in certain parts of both these rivers exhibit, in some seasons, a green tinge in parts of their substance. But it is rare for this greenness to be so pronounced as to interfere seriously with their sale. In October 1895 I examined several of the oysters in the Roach river which were slightly green, but in almost every case the colouration was confined to the branchiæ alone, and did not extend to the labial palps, as it does when the greening is of a more pronounced character. For an account of "green-bearded" oysters the reader is referred to page 99 of this report.

The River Crouch Oyster Fishery.

The oyster fishery in this river is leased from the Lord of the Manor by the Burnham Oyster Company, and the rights of this Company extend, with exceptions to be referred to below, from the mouth of the river at Ray Sand Beacon to Clement's Green Creek, some 16 miles inland. Along the course of the river there are, however, in addition, several private oyster layings, the positions of which are approximately shown on the accompanying map by the areas coloured red. At numerous points along the banks of the River Crouch are pits or excavations used for the wintering or storage of oysters, and the localities of many of these pits may be seen by a reference to the map of the district, where they are indicated by red and green dots, the private pits being coloured red, the Company's pits green.

The operations of the Company consist in dredging and cleansing the grounds, re-depositing immature oysters in certain localities, and laying down oysters at a nearly marketable stage of growth on the fattening beds. These fattening beds are situated at Holliwell, on the area coloured yellow in the map, on the north side of the River Crouch, about three miles eastward of the village of Burnham. In this situation, on the marshes abutting upon the fattening beds, are pits or ponds in which the oysters are deposited for sale and for storage during the winter months. During the summer months other than those covered by the close season, the oysters required for market are taken, I am informed, direct from the fattening beds. In addition to these pits, the Company have others situated near Cricksea Ferry, where oyster brood is stored during the winter. These pits, as also those to which reference has already been made, consist of excavations in the marshes some 2 feet deep, *i.e.*, rather above the average depth of oyster pits elsewhere. It should be stated that in many instances the private merchants in the Crouch River sell brood to oyster Companies requiring it, and do a relatively small trade in marketable oysters.

POLLUTIONS OF THE CROUCH.

As regards sewage disposal in the River Crouch, the sewage of Burnham is conducted to certain works situated on the side of the river at a point distant about half a mile eastward of the village. At these works the original intention appears to have been to have subjected the sewage to subsidence and upward filtration through gravel. It seems, however, that the filtering material being of but small extent, frequently became blocked, and in order to facilitate disposal of the sewage the filtration was dispensed with, and the sewage, after a very indifferent screening, and a mere apology for subsidence, was led direct to the outfall. At this outfall, situated about a mile distant from Burnham, the sewage is discharged into a small creek leading directly into the Crouch. The sewers of Burnham are, I understand, flushed at least twice weekly, and at these times the "effluent" passing away from the works shows no signs of the effect of subsidence or of any other treatment. I visited these sewage works just after the contents of the flushing tanks had—so I was informed—been liberated; and found that the "effluent" leaving the works was conspicuously thick and offensive. On walking to the outfall I found the sewage discharged still in the same condition, and that the sides of the creek at low tide were coated for some distance with thick black deposit. On my return I again examined the works, and during the interval the "effluent" had certainly become much clearer. Obviously, however, the treatment to which the sewage of Burnham was being subjected at the time of my visit was of an imperfect character, and for purposes of purification of

but little value. It will be seen from the map that the "effluent" discharges near to certain private layings, but about $2\frac{1}{4}$ miles from the fattening beds of the Burnham Oyster Company. This is the main pollution of the River Crouch. Looked at in relation to the whole river, the volume of the pollution is perhaps not a very serious matter, but the proximity of the outfall to the private layings referred to would appear compromising to the oysters there situated, while the fattening beds of the Burnham Oyster Company, though, as stated, $2\frac{1}{4}$ miles eastward of the outfall, cannot be regarded as altogether free from risks of contamination by the Burnham sewage.

The risks to which the storage pits of the Company are liable are but small, as any water taken into them would be received on the flood tide, when the amount of sewage in the river must be quite infinitesimal.

Were this source of pollution removed by the adoption of proper means of purification of the sewage at Burnham sewage works, I should see no reason for regarding the oysters taken from the River Crouch, or from the pits abutting upon it, as otherwise than free from risk of sewage contamination, though obviously no oysters should be laid down close to the outfall of the effluent.

N.B.—I am able to record that, owing to the energetic action of Dr. Thresh, who was one of the first Medical Officers of Health in the country to call attention to the risks of contamination of oysters by sewage, the Maldon Rural District Council have, since the date of my visit, taken the steps which Dr. Thresh deemed necessary to purify this effluent.

The River Roach Oyster Fishery.

The Roach River Oyster Company holds a "Several" Order from the Board of Trade under the provisions of the Roach River Fishery Act, 1886, by which the right of an oyster fishery is conferred upon the Company over an area extending from the junction of the River Roach with the River Crouch to a creek known as Potton Creek, some three and a half miles inland. The fattening beds of the Company—whose procedures generally may be regarded as practically identical with those of the Crouch Oyster Company—are situated in and around what is known as Whitehouse Hole, in the position coloured yellow upon the map. In the season 1894–5 this Company sold 350,870 oysters and 530 bushels of brood, while 1,363 bushels of brood, half-ware, and spat obtained from the Company's pits and grounds were laid down.

The storage and wintering pits of this Company are on the northern banks of the Roach, near Paglesham Pool, and in these pits oysters are, as a rule, placed temporarily prior to their despatch to market. I was informed, however, that in some instances the oysters for market are taken direct from the fattening beds.

In the Roach, and in creeks subsidiary thereto, are numerous private oyster layings; in fact all those parts of the Roach and its tributaries not belonging to the Roach Oyster Company may be regarded as being utilised by private oyster merchants, while at intervals along the banks are wintering pits belonging to one or other of the owners of these private layings. The distribution of the private layings is indicated by the areas coloured red on the map, and the approximate positions of many of the private pits by dots coloured red; the pits of the Company being coloured green. It will be seen from the map that the oyster layings extend, not only up the Roach to within some three miles of Rochford, but that they are also situated in Yokefleet and Potton Creeks and the tributaries thereof, as also in Paglesham Pool.

The Pollution of the Roach and its Tributaries.

The River Roach and the creeks connected with it, such as Yokefleet, Potton, and Paglesham, traverse a country which is almost uninhabited; and there can be no question whatever that the vast majority of the oyster layings hereabouts are practically free from sewage contamination. Over the whole area referred to the only pollution is that of the effluent from the Rochford sewage. Rochford is a town of about 1,100 inhabitants, the sewage from which is conducted to a settling tank situated just outside its inhabited area. In this tank the sewage is subjected in some degree to sedimentation and screenage, but although probably some good results from this process in times when but little storm water is entering the sewers, it would seem that after heavy rains the whole volume must pass through the tank at such a rate as to afford but little time for any improvement to take place; the "effluent" from the tank discharges to the Roach. At intervals some carbolic powder is sprinkled on the surface of the liquid in the tanks, and possibly this process may possess some deodorising value; the tank is emptied of its solid contents about twice yearly. There is room for considerable improvement in the treatment of the Rochford sewage.

It should be pointed out that the outfall of this effluent is a long distance above the point at which any marketable oysters are laid down. I am informed, in fact, that perhaps, with one small exception, there are no marketable oysters laid down in the Roach nearer Rochford than East End, over four miles distant from the outfall, while the fattening beds of the Roach River Oyster Company are fully seven miles distant.

Considered generally the oyster layings in the River Roach and in the numerous creeks connected with it are to be regarded as free from serious risk of sewage contamination; in fact, were steps taken to improve the condition of the Rochford effluent, oysters hereabouts might practically be considered as in this sense secure. Indeed in a thickly populated country such as England, it would be difficult to find many more suitable places for oyster culture, from the view point of freedom from pollution, than the creeks abutting upon the Crouch and the Roach Rivers.

THE BLACKWATER AND MERSEA OYSTER BEDS. (Map, No. 3.)

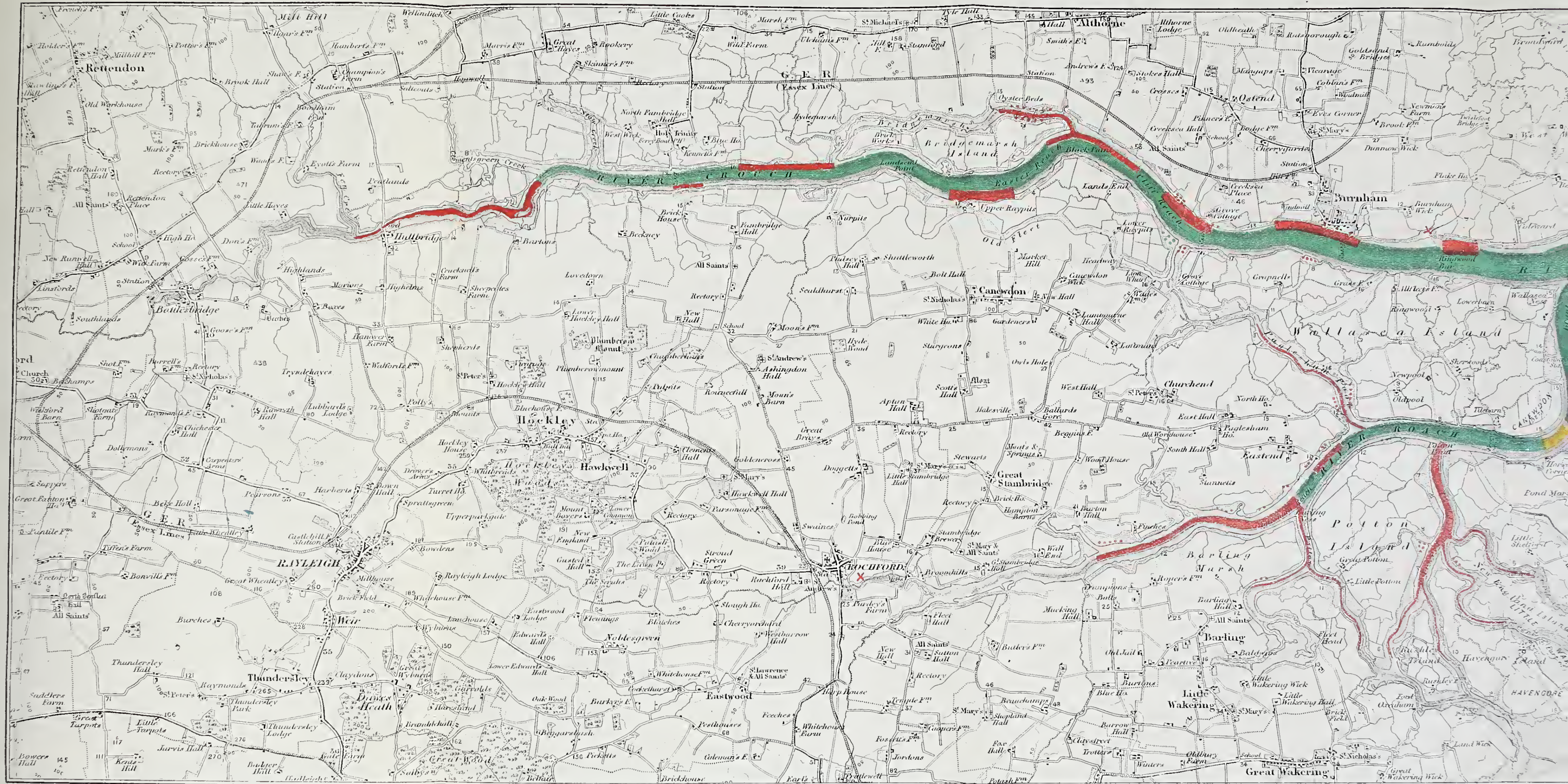
The estuary of the Blackwater extends from Maldon to Mersea Island, a distance in all of some 12 miles. At Maldon the River Chelmer enters the estuary, and between this town and Mersea several tributaries discharge. On the northern side of the estuary, near to the sea, are some large creeks, notably Tollesbury Fleet, Salcott Channel, Little Ditch, Thorn Fleet, and Mersea Fleet. Nearer Maldon there are others, such as Goldhanger and Thornbury Creeks; and on the south side of the estuary are Lawling and Bradwell Creeks.

The Blackwater at high tide presents a very large expanse of water, and even at quite low tide its volume is very considerable; in fact, next to the Thames, it is certainly the largest estuary on the coast of Essex.

Over the area indicated there are very extensive oyster layings in addition to the native produce of the locality, which is at times large.

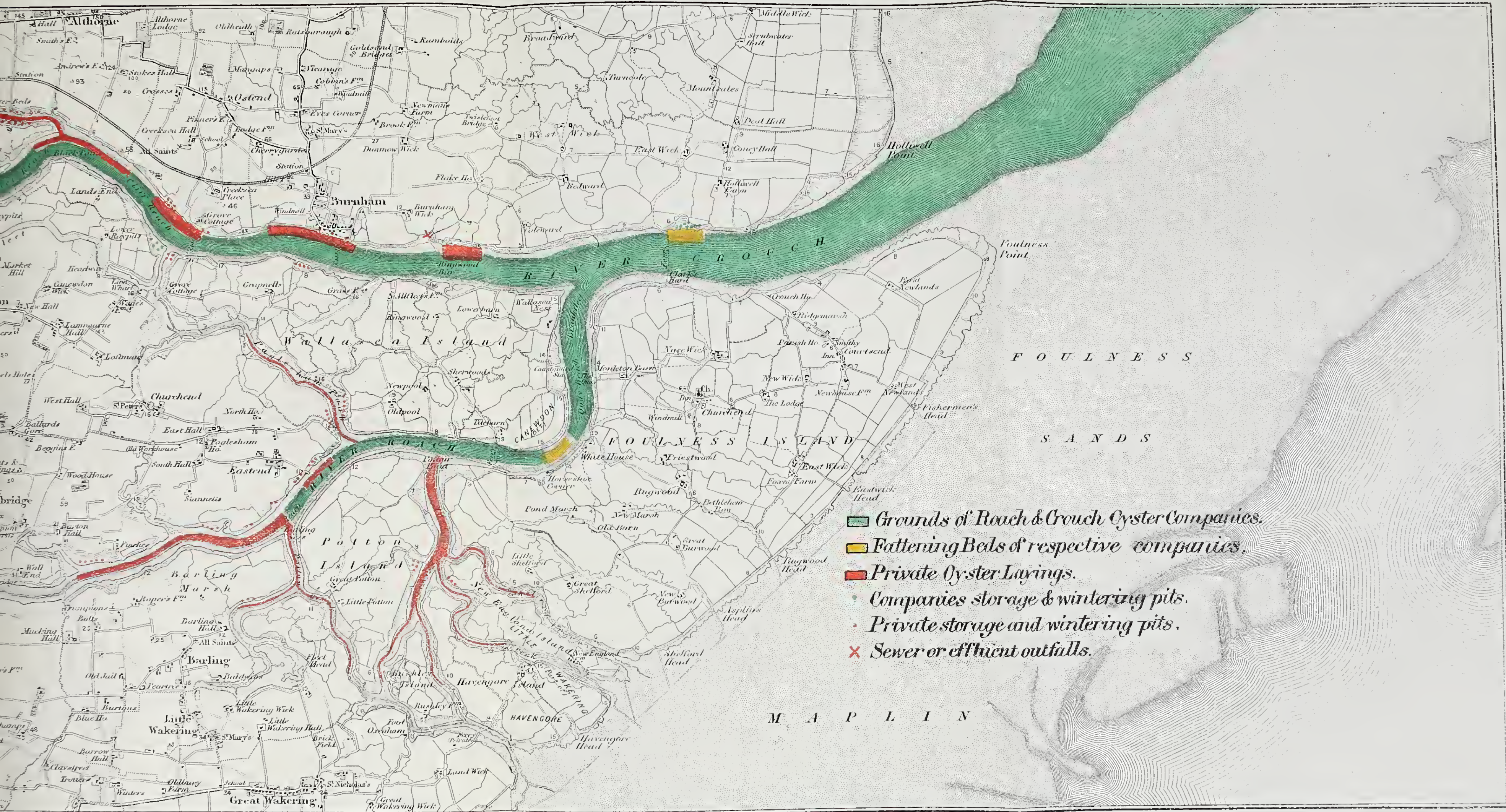
Formerly oysters were cultivated in the Blackwater estuary, some 1½ miles nearer to Maldon than is the case now, by a company known as the Fish and Oyster Breeding Company, Limited. At the present time the operations for oysters do not extend westward of Thurslett Fleet, a point about midway between Maldon and the mouth of the Blackwater.

MAP TO SHOW THE APPROXIMATE POSITIONS OF THE OYSTER LAYINGS ETC IN THE



POSITIONS OF THE OYSTER LAYINGS ETC IN THE CROUCH & ROACH RIVERS.

Map N° 2.



- Grounds of Roach & Crouch Oyster Companies.
- Fattening Beds of respective companies.
- Private Oyster Layings.
- Companies storage & wintering pits.
- Private storage and wintering pits.
- Sewer or effluent outfalls.

The chief company having rights of an oyster fishery in this estuary is that known as the Tollesbury and Mersea (Blackwater) Oyster Fishery Company, Limited, which Company, under an Order of the Board of Trade, holds fishery rights over so much of the Blackwater as extends from Thurslett Creek landward to a line drawn across the estuary at the seaward limit of Bossom Fleet, and comprising also the waters of Thurslett Creek, Virley Channel (Deeps), and Thorn Fleet.

The operations of the Company consist in the usual preparation of the oyster ground, of the transport of brood on to certain prescribed areas, and of the deposition of oysters for fattening in what is known as the Deeps, situated in Virley Channel. During 1894-5, 844,700 oysters were sold from the waters of this fishery, and brood procured by dredgers on the public grounds was purchased and laid down by the Company to the extent of 2,855,000.

On Packing Marsh Island are numerous oyster pits, in which the water is renewed only at spring tides. Some are used for wintering brood, others for the storage of oysters prior to their despatch to market. The oysters are sorted and packed up in a packing house on this island. The greater part of the oysters of this Company are despatched, I am informed, to Ostend and Dunkirk.

In Bradwell Creek, on the south side of the estuary, are two private layings; and on the marshes near, a storage pond.

The Layings in the Tollesbury and Mersea Fleets. (Map, No. 3.)

These creeks are, for the most part, the property of private owners, by whom they are let to different oyster merchants in small strips of some 100 feet or so in width, each strip being beaconed off from the others.

In Mersea "Fleet," at that part of it which is situated between Packing Marsh Island and Cobmarsh Island, are fattening beds belonging to a private oyster merchant, who also has wintering pits on Cobmarsh Island. Above these fattening beds a section of this "fleet" is used for the anchorage of fishing craft, &c., and hereabouts there are no oysters laid down; then the layings recommence. On the foreshore, near Stonehill Hard, are some wintering and storage pits belonging, some of them, to the Colchester Native Oyster Company, some to a private oyster merchant, and in the neighbourhood of these pits is a packing house from which the oysters are despatched to market. As a general rule oysters belonging both to this Company, and oysters belonging to the merchants already referred to, are deposited prior to despatch in these storage pits.

In Salcott Channel and Little Ditch, as also in North Channel and Tollesbury Fleet, are numerous layings, some of which belong to a company, some to private merchants.

In what is known as the South Channel of Tollesbury Fleet, oysters are laid down only as far inland as the mouth of Woodroffe Creek.

Certain portions of these creeks are used for growing oysters, others for fattening purposes only. In the case of private beds, hereabouts, the lessees of which have no storage pits, the oysters are despatched direct from the beds to market. But some of the oyster merchants have storage pits far removed from their layings; for instance, two merchants having layings hereabouts possess storage pits at Wivenhoe, referred to under the heading of "The Wivenhoe Storage Pits" (see page 40).

As regards the Sewage entering the Blackwater and its Tributaries.

The main polluting agency of the Blackwater is the sewage of Maldon, a town with a population, at the last census, of 5,397. This sewage is

conducted some distance outside of the town, and is held up during high water in storage tanks, the only treatment to which it is subjected being a coarse screening. The sewage, after screening, is discharged into a creek on the marshes, and eventually finds its way into the Blackwater at a point some 12 miles distant from its mouth, near Mersea Island.

At Heybridge, opposite Maldon, a large portion of the sewage of Heybridge passes into a creek, which shortly afterwards joins the Blackwater. At one point along this creek are a number of privies discharging direct on to the foreshore, a condition of affairs which should receive the serious attention of the Maldon Rural District Council. At Heybridge Basin a small group of houses discharges sewage direct into the Blackwater.

The village of Tollesbury discharges its slop and storm water (excrement is disposed of chiefly by pails and privies) by means of two outfalls. The larger of these empties itself on to the marshes, and some of the sewage in all probability finds its way, after a sinuous course, into Woodroffe Creek, a tributary of Tollesbury Fleet. In Woodroffe Creek there are no oysters laid down. At the time of my visit to this outfall, when I was accompanied by Dr. Thresh, the county Medical Officer of Health, but little sewage was escaping from it, and it was not possible to trace the sewage by the naked eye even as far as the commencement of Woodroffe Creek. It is, however, possible—indeed, probable—that after heavy rain the flushing of the sewer might tend to the sewage being visible in the water of the creek for a considerable distance.

The sewage discharged at the second and smaller outfall passes first into a catch-pit, where some of the suspended matter is intercepted, and the remainder discharges at once into a ditch distant about a mile from Old Hall Creek, another tributary of Tollesbury Creek.

The only other pollution to be here recorded is at West Mersea, where a drain from some 20 houses discharges on to the foreshore just landward of the "Victory" public-house, and some 43 yards distant from some storage pits belonging to a private oyster merchant. This pollution I consider to be the most serious, from the standpoint of the oysters, of those I have here referred to.

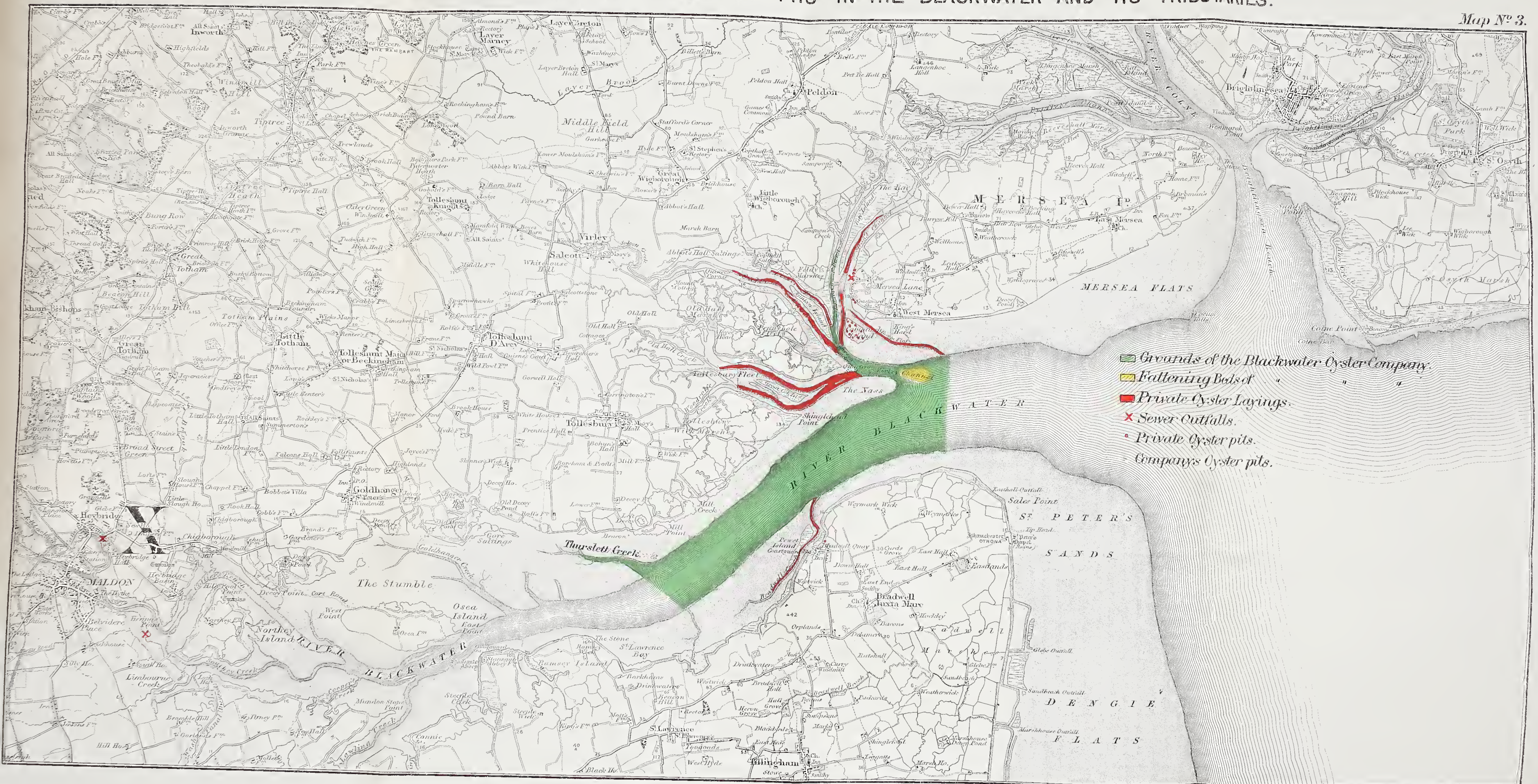
An inspection of the map annexed will show that, as regards the River Blackwater, west of Thurslett Creek, no sewage discharges into it at a point less than ten miles distant from the nearest fattening beds of the Tollesbury and Mersea Oyster Company, while some of the sewer outfalls are at a greater distance than this. It will be observed, too, that the fattening beds here referred to are outside the channel of the estuary. Having regard to the circumstance that 11 miles of river intervenes between the Maldon and Heybridge outfalls and the fattening beds in the channel and creeks of the Blackwater, and the fact that the estuary, in the neighbourhood of the fattening beds, is nearly two miles across at high tide, it would appear that danger of sewage pollution of the oysters on these beds cannot be other than very remote. And the same may be said of oysters in pits hereabouts, with the exception of those stored in the pits near the "Victory," at West Mersea, to which I have specially referred.

THE RIVER COLNE OYSTER FISHERY. (Map, No. 4.)

The fishing in this river, both for floating and bottom fish, has from "time immemorial," according to the words of the Colne Fishery Act, 1870, been vested in the Corporation of the borough of Colchester and of the town clerk of that borough I am indebted for much of the

MAP TO SHOW POSITION OF OYSTER LAYING AND PITS IN THE BLACKWATER AND ITS TRIBUTARIES.

Map No. 3.



information here given. It is needless to enter into the past history of the fishery, save to remark that owing to certain difficulties in administration the Act above quoted was passed, and the fishery is now carried on according to its provisions. By virtue of this Act the Corporation of Colchester let to the Colne Fishery Company the fishing in the river for a period of 90 years. It is enacted, however, that the fishery shall be managed by a Fishery Board, consisting of 12 persons annually elected, six being members of the Corporation, and six members of the Company. The chairman, who must be a member of the Corporation, has no casting vote, and in the event of a deadlock occurring, provision is made for arbitration by the Board of Trade.

The potential limits of the fishery are set forth by the Colne Fishery Act, 1870, as extending along the River Colne from North Bridge, in the borough of Colchester, to West Ness, near Colne Point.

The area covered by the actual operations of the Company at the time of my visit was, however, of a much more limited extent than this, being confined to that portion of the river extending for about half a mile landward of West Ness, near Colne Point, to a short distance landward of Geetong's Creek. I was, however, given to understand that with the development of the Company's operations, the grounds may eventually extend as far towards Colchester as Beacon's Hard, but not beyond; and consequently the river is coloured green on the map up to this latter point. The operations of the Company are easily explained. Native brood—either that caught on the Company's own ground, or dredged up by dredgers on the Essex Flats—is laid down to grow in the Colne estuary over portions of the river above indicated. In the spring of each year oysters which will become marketable in the following autumn would generally appear to be dredged up from the river, and laid down on the fattening beds. These fattening beds are situated some distance up the Pyfleet, a tidal channel separating Mersea Island from the mainland, and in a quite uninhabited district. During the winter Pyfleet oysters are housed in ponds on Peewit Island, as also is much of the oyster stock belonging to the Company; on this island is also a packing house from which oysters are despatched to market.

At the time of my visit to the Colchester Fishery, dredging boats were engaged in moving nearly marketable oysters from the Colne estuary to the fattening grounds in the Pyfleet. The dredging boats, after having performed a stated amount of work, bring their catch at a given signal to, what is known as, the flagship, the oysters being transferred from the dredging boats to the flagship by means of small rowing boats. The number of oysters dredged up by each boat is carefully recorded in a register at the time of their arrival at the flagship. The delivery being completed, the dredging boats are compelled to remain at anchor until a search visit has been made in a steam launch by the Colne police, and not until the signal is given from the flagship are the dredging boats at liberty to disperse. The flagship with the oysters on board is then taken to the Pyfleet, and the oysters scattered over certain prescribed areas. Oysters laid down in the Pyfleet rapidly undergo a remarkable change in appearance and flavour, more especially in what are regarded as favourable years for "fishing," *i.e.*, fattening. Oysters in the Pyfleet never became green-bearded, though on the other side of the roadway joining Mersea Island to the mainland (the Strood) this greening is often marked. During my inspection of the Colne fishery I was accompanied by, and received much assistance from, Mr. Newman, manager of the Colchester Oyster Company.

As to pollutions of the River Colne.

Colchester, with a population of 34,559 at the last census, discharges its effluent into the river, after treatment with lime and sulphate of alumina, at a point $1\frac{3}{4}$ miles below Colchester East Bridge where the river is at low tide of but very small dimensions. This is five miles from the nearest oyster layings, and six miles from the mouth of the Pyfleet. The method of sewage treatment at Colchester seemed to be carefully carried out at the time of my visit and to be such as to reduce enormously the number of organisms originally present in the sewage. At the village of Rowhedge, distant about $1\frac{1}{2}$ miles below the Colchester outfall, are several small drains discharging into the Colne, and at Wivenhoe, a small place about a quarter of a mile seaward of Rowhedge, and on the opposite side of the river, are also other drains discharging on to the foreshore. At Brightlingsea, with a population considerably over 3,000, the untreated sewage of that place passes into Brightlingsea Creek; but this creek is separated by the whole width of the estuary of the Colne from the Pyfleet where the Company's fattening beds are situated. Into the Pyfleet itself no drains whatever discharge.

After a careful consideration of all the facts, and taking account of the set of the tides in the Colne, it appears to me that oysters laid down in the Pyfleet or stored in the pits on Peewitt Island are practically free from risk of pollution. Provided, therefore, that all oysters prior to consumption are laid down for a sufficient period on the fattening grounds of the Pyfleet, there is probably no reason to suspect the wholesomeness of Colne Fishery oysters, but it seems to me very undesirable that oysters should be despatched from market direct from the bed of the River Colne.

There are certain layings in Geetong's Creek, to the north of the Pyfleet, which belong to a private oyster company, and the same remarks, as regards sewage pollution, would apply to them as to those in the Pyfleet.

The Wivenhoe Storage Pits. (Maps, Nos. 4 and 5.)

On Wivenhoe Quay, in positions indicated by the accompanying map, are two pits used for the storage of oysters, brought from elsewhere, prior to their despatch to market. These pits belong to different owners, but the position of each pit is such as court the contamination by sewage of oysters therein contained. In each instance there is within a few yards of the intake to the pit a drain serving a considerable number of houses. These pits are, I was informed, frequently emptied and scrubbed out, but having regard to the facts that I have noted, this practice does little to diminish the serious risks to which oysters in these pits are exposed.

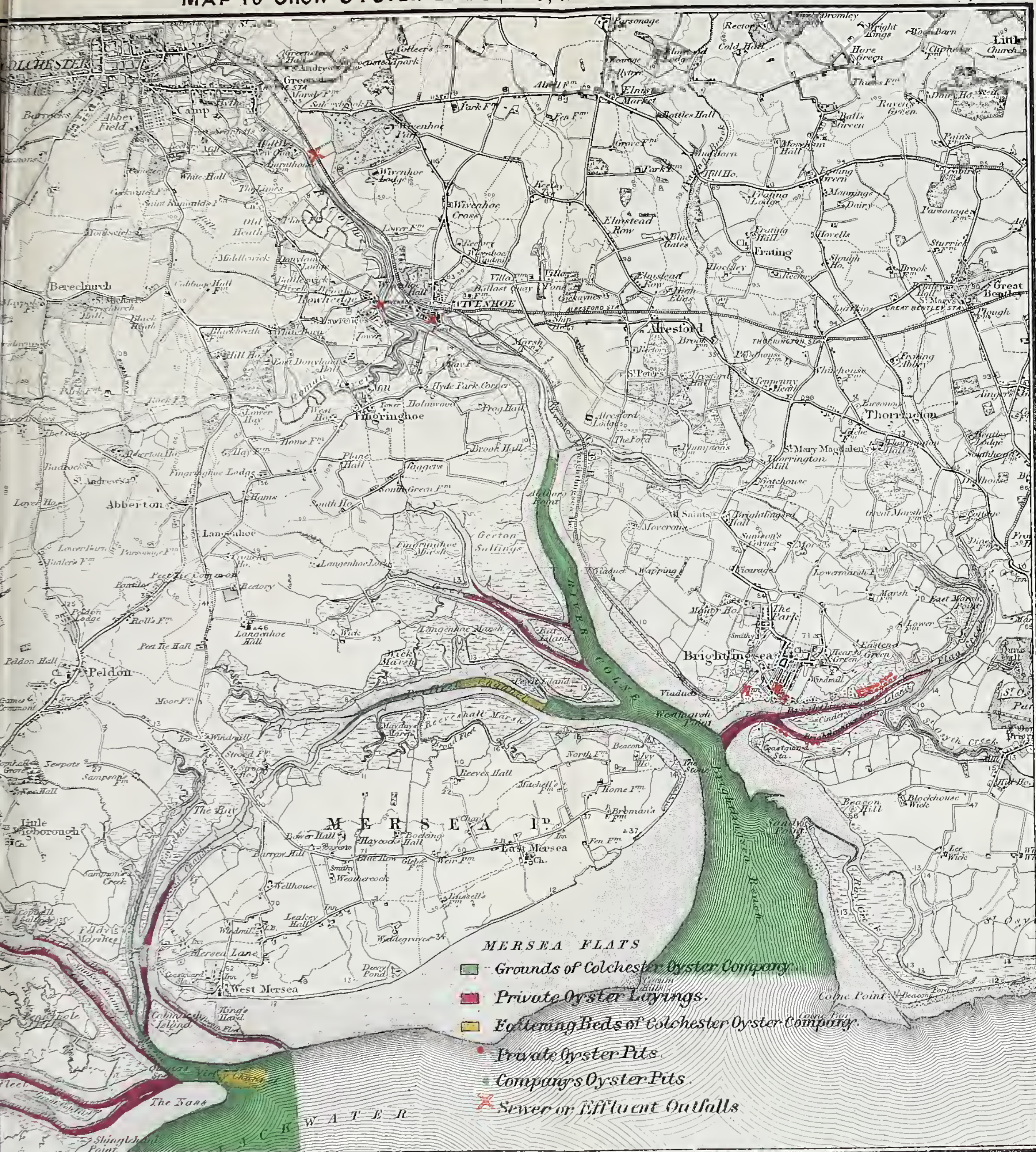
The Oyster Layings of Brightlingsea Creek. (Maps, Nos. 4 and 6.)

Brightlingsea Creek, which is formed by the junction of Flag Creek with a tidal stream from the village of St. Osyth, enters the River Colne a short distance beyond Brightlingsea. That part of the creek which is utilised for oyster layings extends from its junction with the Colne to the landward extremity of Cindery Island, which island hereabouts practically divides the creek into southern and northern portions.

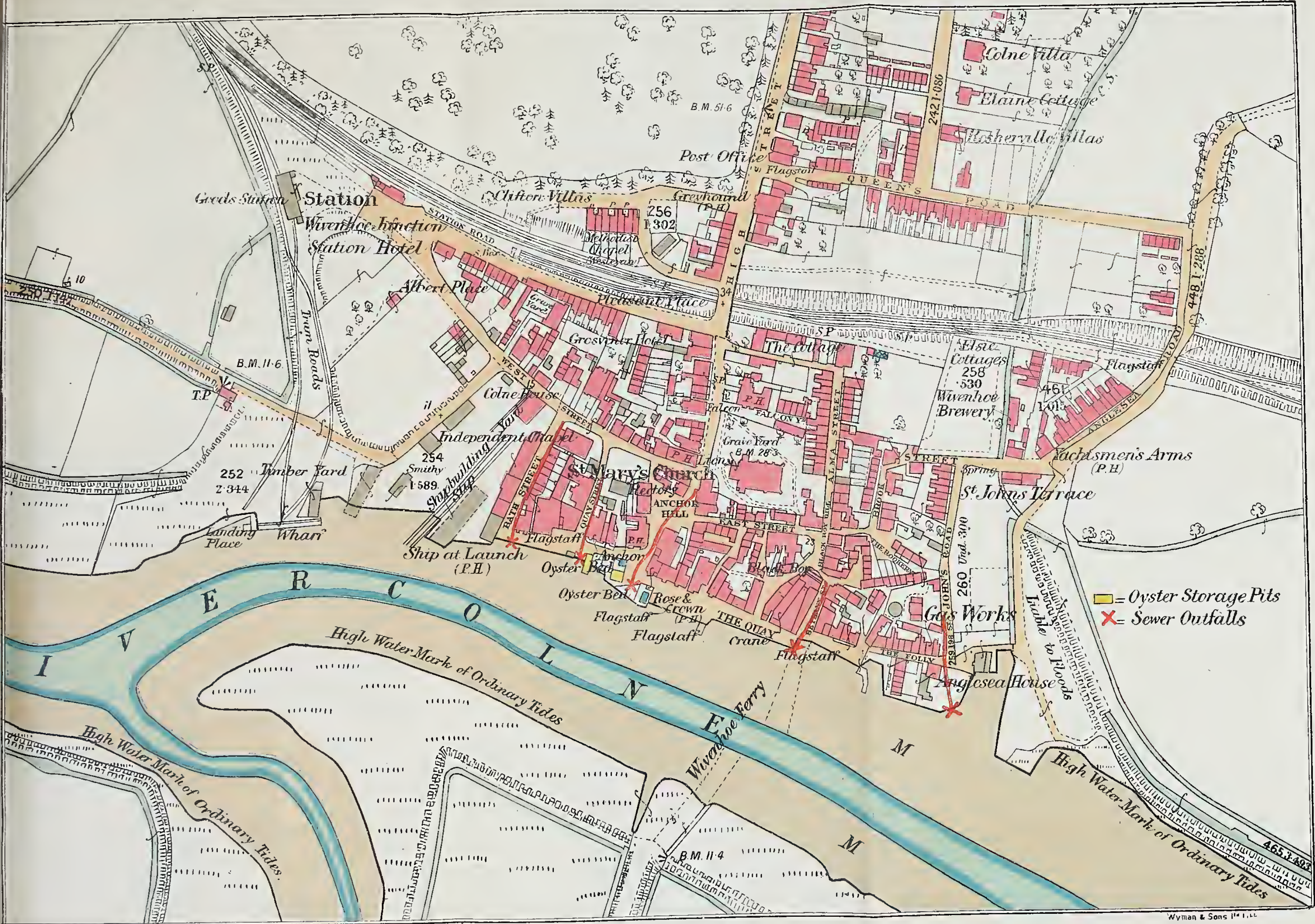
Within the limits mentioned are numerous oyster layings of varying dimensions, from which oysters are despatched direct to market; as an average the layings measure about 100 yards in length, their limits being marked out by beacons; in some instances the layings extend the whole width of the creek, in others only half the width.

MAP TO SHOW OYSTER BEDS, ETC., IN AND AROUND THE COLNE.

Map. N^o 4.



MAP TO SHOW THE RELATIVE POSITIONS OF THE WIVENHOE STORAGE PITS TO THE WIVENHOE SEWER OUTFALLS. Map 5.





Map No 6.



Near Brightlingsea ferry, where vessels are by common consent moored, and over a considerable area of the creek to the south of the seaward end of Cindery Island, there are no oyster layings; nor do layings extend on this side of the island eastward of Pincushion Island. As a general rule, foreign oysters only are deposited in Brightlingsea Creek, and at the time of my visit a large consignment of American oysters had just arrived, which oysters were being deposited on some of the layings. The oysters are laid down for varying periods from a few weeks to a year. During the winter months, as a general rule, such oysters as remain unsold are taken from the layings and deposited in wintering pits in the marshes near at hand. Near Brightlingsea ferry, on the town side (see Map 6), are two storage pits, constructed with cement floors and wooden sides, where the oysters of certain merchants are stored prior to sale.

The sewage of Brightlingsea is discharged by three separate outlets on to the foreshore in positions diagrammatically represented on the accompanying map. At the time of my visit, each of these outfalls was discharging offensive matter; the middle one, that passing through Mr. Stone's yard, being particularly offensive. Near to the points of discharge on the foreshore of the creek are numerous oyster layings, and at low tide the sewage may be seen emerging from the outfalls, and after passing over the mud, running along the back of the oyster layings hereabouts. Under these circumstances it is difficult to understand how the oysters near can fail to be polluted thereby. It may be added, too, that some of the oysters laid down in the locality just referred to are afterwards stored in the cemented pits to which reference has just been made, and it would seem that polluted oysters thus introduced into the pits might lead to the contamination of others.

In reference to the sewage of Brightlingsea, it should here be remarked that some years ago it was proposed to carry an intercepting sewer to an outlet at Westmarsh Point, but this proposal was stoutly opposed by the fishermen, who advocated the carriage of the sewage to the marshes and its treatment thereon. There can be little doubt that the oyster layings near the Brightlingsea outfalls are in especial danger of sewage pollution, and Dr. Cook, the Medical Officer of Health of the district, has taken energetic steps to bring about a better state of affairs, but hitherto his efforts have been unavailing.

Brightlingsea is a rapidly increasing town, and danger of contamination of oysters laid down here will tend to materially increase with the addition of new houses, unless steps are taken for the proper disposal of the sewage.*

HAMFORD WATER OYSTER FISHERY. (Map, No. 7.)

The right of a "several" oyster and mussel fishery here was conferred upon Mr. John Smith, of Burnham, Essex, by the Oyster and Mussel Fisheries' Order Confirmation Act, 1883. The limits of the fishery are set out in the usual manner in the Order, and without relating them in detail they may be held to embrace all the channels below low-water mark of ordinary neap tides, of Hamford Water, and of certain portions of Oakley, Lendermere, and Kirby Creeks - a total area of some 900 acres. It seems, however, that in recent years, little has been done here in the matter of oysters, whether native or foreign, and at

* Since writing the above, definite allegation has been made to the effect that enteric fever has followed on the consumption of oysters procured direct from the foreshore near the sewage outfalls of Brightlingsea. However, this may be, there can be no question as to the risk to which oysters deposited on the Brightlingsea foreshore are liable.

the time of my visit in June 1895 operations had ceased. When the lessee made use of these grounds his operations were, I understand, chiefly confined to certain portions of Hamford Water and Kirby Creek. In those places the areas which were pointed out to me as having been thus utilised were practically free from sewage pollution, in fact, the land hereabouts is but very sparsely populated. It seems that some years ago attempts were made to reclaim certain portions of the tide-washed marshes abutting upon Walton Channel and Hamford Water, and embankments were erected for the purpose. These however, eventually burst, and it is stated that the amount of detritus, &c. then carried landward has detracted from the value of the creeks hereabouts for the purpose both of oyster laying and breeding. In inspecting this district, Mr. Smith, the lessee, was good enough to place a boat and crew at my disposal.

THE RIVER ORWELL OYSTER FISHERY. (Map, No. 8.)

Within recent years there has been but little "native" spat in this estuary, and the fishing grounds as such are at a discount. There are however ponds adjoining the river in which oyster breeding has, with varying degrees of success, been carried on for several years. The rights of oyster fishing in the Orwell itself are let by the Corporation of Ipswich to a private oyster merchant, these rights extending from Shotley Point to Stoke Bridge, in Ipswich, *i.e.*, over practically the whole of the estuary. The actual operations have, however, for many years past been confined to Lower Reach, or to so much of the river, about two miles in extent, as is comprised between Collimer Point and Shotley Point, near Bloody Point namely, that portion nearest the sea. Between these limits foreign oysters are laid down at intervals and natives are dredged for. I am informed by the lessee of this fishing that as a general rule oysters for market are taken direct from the river, but on Shotley marshes, on the west bank of the river, alongside the layings, are a storage pit and a wintering pit where oysters are occasionally deposited. There are too, near the pits, certain ponds which have been used for breeding purposes for many years, and which are still annually put to this use. The pits and ponds here referred to are fed at quite high tide through the agency of sluices from a small tidal channel communicating with the river. In the breeding ponds "collectors" of various kinds have been used, such as cemented tiles, splines with oyster shells attached to them, &c., but although these experiments have been carried on for many years, only poor success has attended them.

The Orwell Park and Fagborough Breeding Ponds.

These ponds, which are situated on the eastern side of the Orwell, are the property of Captain Pretyma, M.P., who has taken much interest in the subject of oyster culture.

The Orwell Park Ponds are in a secluded and sheltered spot in the park, in a position almost immediately opposite the hamlet of Pin Mill, about midway between Ipswich and the mouth of the estuary. Water is admitted to the breeding ponds by means of a sluice, communicating with the Orwell, and in such a position that the ponds can only be filled at spring tides. The experience as regards oyster culture in these ponds seems to have been an encouraging one, and fairly uniform success appears to have been obtained. The spat here is for the most part received on wooden splines, upon which oyster shells are fixed,

MAP TO SHOW OYSTER GROUNDS IN HAMFORD WATER.

Map No 7.



FOLDOUT B

PSWICH

SEWER OUTFALL



Woolverton

Woolverton

Woolverton

Woolverton

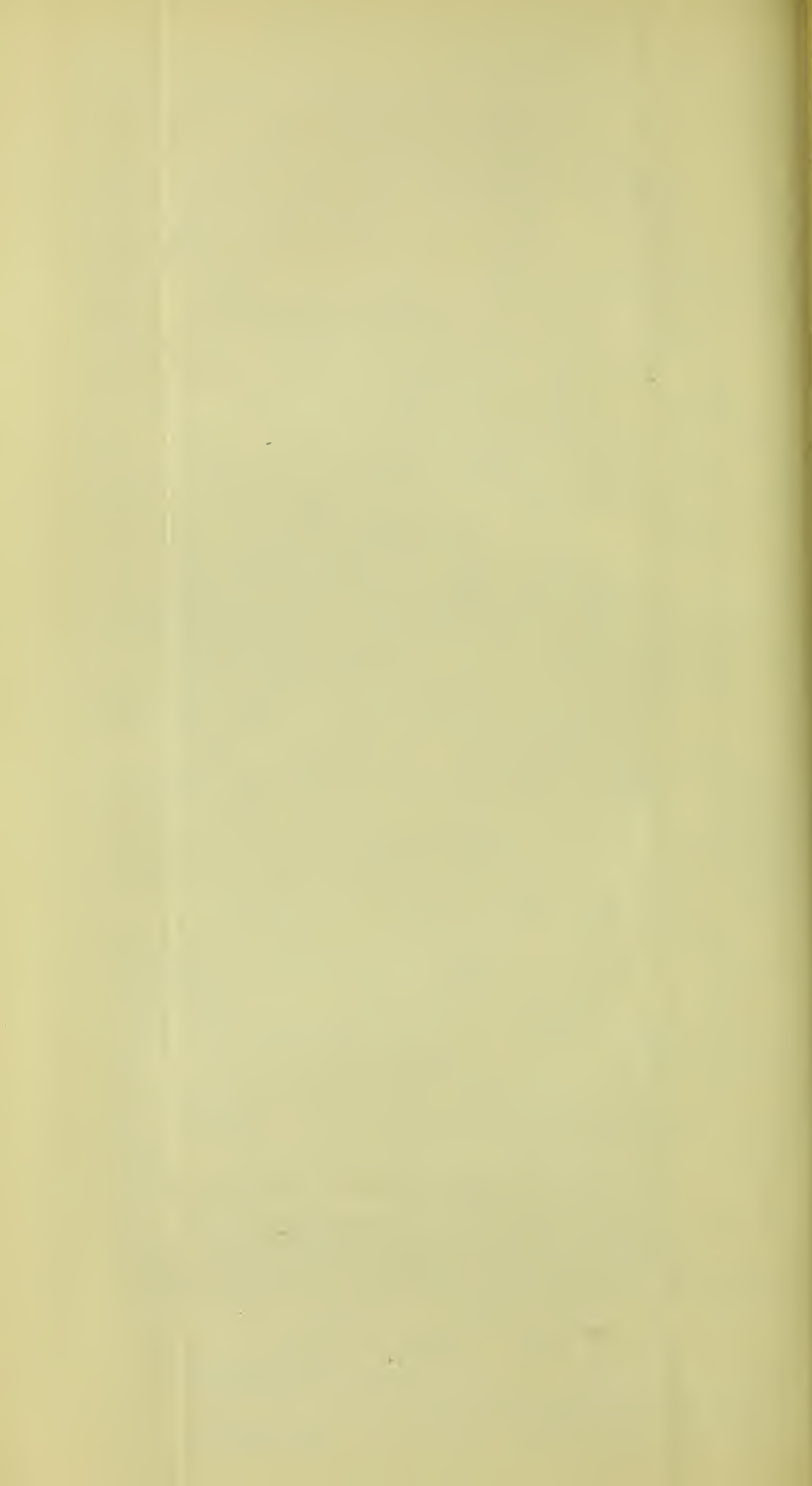
Woolverton

Woolverton

Woolverton

Woolverton

Woolverton



and which are supported off the bottom of the ponds by wooden rails. As a general rule oysters bred in these ponds are sent when about two years old to other ponds at Fagborough, now to be described, from which ponds they are sold to oyster merchants for re-laying and fattening.

The Fagborough Ponds are situated in the parish of Trimley, at the mouth of the Orwell estuary, and they are fed with salt water by means of a channel communicating with what is practically Harwich Harbour, a large body of water formed by the convergence of the Orwell and Stour estuaries. In these ponds the arrangement as regards breeding are practically identical with those referred to in Orwell Park. I am informed that only on rare occasions are oysters despatched from these ponds to market, the usual course being the despatch of the two year old brood for relaying in other waters.

Pollutions of the Orwell.

The chief pollution of the River Orwell is the sewage of Ipswich,* a rising town having at the last census a population of 57,260. The sewage is received into a storage tank, situated on the eastern bank of the Orwell, at some distance from the town (see red cross on map). It is here subjected to screening and to a certain degree of subsidence; no precipitants are used. The sewage after this treatment is let out on the ebb-tide, and the discoloration of the water caused thereby can be traced down the river for a very considerable distance from the outfall. The distance at which the sewage can be detected varies with the condition of the surface of the water, the amount of upland water in the river, and the general condition of the atmosphere as regards temperature and wind. I have myself traced the discoloration caused by the sewage, even under conditions of wind, &c., unfavourable to observations, fully two miles below the outfall, and I am informed that under favourable conditions it may be detected nearly as far down as Pin Mill. The sewer outlet is at a distance of six or seven miles from the nearest point of the river at which operations for oysters are carried on. The river at Collimer Point is, even at low tide, over a quarter of a mile, and at high tide nearly half a mile, in width; while the depth over a large area is as much as four fathoms.

Having regard to the several miles of water-way intervening between the point at which Ipswich sewage is discharged into the Orwell and the oyster layings in Lower Reach, as well as to the enormous bulk of water with which the sewage can become mingled before arrival over the oyster beds, the layings in question are to be thought of as perhaps little exposed to risk of contamination. But so long as the crude sewage of Ipswich continues to be discharged into the river it would be proper that oysters should be deposited and retained for a while, before they are delivered on the market, in the storage pits hereabouts, to which water is admitted only at high tide.

THE RIVER DEBEN OYSTER FISHERY. (Map, No. 9.)

Under the Ramsholt Fishery Order, 1884, as confirmed by the Oysters and Mussels Fisheries' Order Confirmation Act, 1884, the right of an oyster fishery in part of the River Deben was conferred upon an oyster merchant. The limits of the fishery extend from just above Ramsholt

* Hermite solution is added to the sewage in certain localities, but the system is apparently used rather in an antiseptic or deodorising sense, than with a view to sterilise the sewage.

Ferry to the entry into the Deben of the King's Fleet, the total area comprised within these limits being 199 acres. The actual operations appear, however, to be confined more particularly to the upper portion of the ground, *i.e.*, that lying at and just below Ramsholt Ferry.

Hereabouts, brood imported from other quarters is, I am informed, laid down, and the oysters grown therefrom are either despatched direct from the beds to market or sent to other grounds for fattening purposes. There are, on the saltings on the east bank of the river some distance below the ferry, storage and wintering pits. The most landward portion of the layings is situated some $s.x$ miles from Woodbridge, which town, with a population of from 4,000 to 5,000 persons, drains direct into the river; while at Melton the Suffolk County Asylum, which contains some 700 inmates, is sewered into this river. Having regard, however, to the relatively small volume of sewage entering the estuary, to the distance of flow before the layings are reached, and to the large volume of water into which the sewage is discharged, the risk of dangerous pollution to the oysters laid down where indicated is probably not great; and, were the oysters, prior to sale for food, deposited for a while in the storage pits, such risk as may perhaps obtain would be avoided.

THE ORFORD RIVER OYSTER FISHERY. (Map, No. 9.)

The oyster fishery in this river, the property of the Orford Trust, was, at the time of my visit, not being worked. Until about two years ago this fishery was carried on by a Company, but owing to a variety of causes it was unproductive and was abandoned. There are, it appears, in this river a large number of "five-fingers" (starfish), mussels, and other competitors of the oyster. The fishery extended from about one mile above Orford Quay, near the town of Orford, to the mouth of the river. The experience of those who have carried on oyster farming in this river is to the effect that the oyster develops there in a satisfactory fashion, but does not readily fatten.

THE OYSTER LAYINGS IN BUTLEY CREEK. (Map, No. 9.)

This creek, a tributary of the Orford River, which it joins just to the South of Havergate Island, is hired by an oyster merchant; only a small portion of the creek is used, this being mainly for the purposes of oyster fattening, *i.e.*, a strip of water extending about half a mile landward of Butley Ferry. Near this ferry is an oyster storage pit, lined with cement and covered with a wooden shed; near to this again is another pit—an open one—also cemented, which is used for storing water to supply the former pit during such times as the water in the creek is rendered muddy by storms; on the marsh near by are also wintering pits. The lessee of the fishing lays down oysters for fattening in the neighbouring creek. These, when required for market, are dredged up, and either deposited for a few days in the storage pit or despatched at once to customers. This creek and the storage pits in connexion with it seem to be in no way exposed to sewage pollution.

MAP TO SHOW POSITIONS OF OYSTER LAYINGS AND PONDS IN THE RIVER DEBEN AND IN BUTLEY CREEK. Map No. 2.



OYSTER LAYINGS ON THE NORFOLK COAST.

In former years there were extensive oyster layings in creeks of the salt marshes near Blakeney, Stiffkey, Wells, Overy Staithe, Brancaster Staithe, and other places thereabouts. These layings flourished when there existed off the Norfolk Coast, and in the Wash, large natural oyster beds; but the gradual exhaustion of these natural sources of supply has reduced the oyster-laying industry here to very small dimensions. As a general rule but very few oysters are now obtained from local beds by the fishermen, and these are for the most part despatched direct to market. But at some of the places mentioned above, *i.e.*, Blakeney, Overy Staithe, and Brancaster Staithe, ponds or pits on the foreshore, which are used in the main for the storage of mussels—and in some instances cockles—antecedent to their despatch to market, are also at times used for the storage of oysters awaiting sale. These ponds or pits are similar in construction to those described in other parts of this report; some of them are paved with cement, others with brick, &c., while in most instances the sides are lined with wood. Occasionally oysters are deposited in creeks of the salt marshes.

The creeks in the marshes which were pointed out to me as being at times used for laying down oysters, appeared to be free from dangerous pollution, but in the case of a few layings sufficient care in this respect did not seem to have been exercised. The oysters are, I was informed, laid down in places which seemed suitable to their development. At Wells, layings for oysters were found unnecessarily near to the drains discharging at the town quays, and were thus not altogether free from the risk of pollution at certain states of the tide.

THE CLEETHORPES OYSTER LAYINGS. (Map, No. 10.)

The town of Cleethorpes is a rapidly rising watering place, situated on the southern bank of the River Humber, about three miles eastward of Grimsby Docks, and about the same distance west of the mouth of the estuary.

These oyster layings, of which there are some 40 or 50, may be regarded in large part as storage depôts, oysters being deposited here for supplying the trade during such times as the direct importation of American oysters is in abeyance owing to the high temperature of the summer season. The layings in question cover a somewhat irregular shaped area about three-quarters of a mile in length and in breadth, those nearest Cleethorpes being distant rather over half a mile from high-water mark. The different layings are marked off from one another by stone heaps and by beacons. As will be seen by the map, the western extremity of the layings is under cover of a sandbank, which dries early on the ebbing of the tide. The whole of the layings are rarely, if ever, entirely uncovered, but a considerable number of those nearest Cleethorpes are visible at or near low water of ordinary spring tides. The surface of the layings consists of fairly firm sand, and this, at the time of my inspection, presented a cleanly appearance. Oysters, chiefly those procured from the North Sea and those imported from America, are laid down here in the spring of the year, and they are despatched to market from Cleethorpes as required, the oysters being brought ashore and packed up in a storehouse either in bags or barrels. As a general rule, the oysters laid down at Cleethorpes are cleared off the beds by October, the situation of the

layings being such as to expose them to the influence of the heavy seas which in winter break upon the coast hereabouts, and which tend both to displace the oysters from one laying to another, and to smother some of the layings with sand. The trade done from Cleethorpes in American and "deep-sea" oysters is a very large one, and the industry an important feature in the trade of Cleethorpes; in fact, this place may be regarded as, in summer, the great distributing centre of oysters of the above sort over a large part of the country, including many of our principal towns.

The Grimsby Oyster Trade.

Grimsby, like Cleethorpes, is situated on the south of the Humber. It is distant about six miles from the mouth of the estuary, and about 18 miles by river from the town of Hull. With respect to the oyster industry, it may be said in general terms that Grimsby, during such times as the Cleethorpes layings are, for the reasons above set forth, disused, forms a centre of oyster distribution for this part of the country. In fact, during the winter months, large quantities of "deep-sea" oysters are brought by "welled" smacks into Grimsby, and are for the most part stored there pending demands for them necessitating their despatch to market. In addition to "deep-sea" oysters, large quantities of American oysters are sent by rail from Liverpool to Grimsby, where they are similarly stored until required.

The oysters of both kinds are, pending their distribution, stored in what are called "floats," *i.e.*, large wooden trays attached to the piers in the Grimsby Fish Docks. The Fish Docks in which these floats are situated are two in number, and have a combined area of 23 acres, that of No. I. being $13\frac{1}{2}$ acres, that of No. II. $9\frac{1}{2}$ acres; they communicate with the Humber by means of sluice gates situated to the north of what is known as No. I., or the old fish dock, and the docks themselves are in communication with one another. Along the western side of No. I. dock and the northern side of No. II. are wooden stages open at the sides, but roofed, where the fish from the fishing smacks and steam trawlers are landed, packed, and despatched to market, while the other parts of the docks are uncovered stages similar in construction. The oyster "floats" which are large wooden trays, are situated beneath or near to the piers, in positions indicated by green dots on the map, there being two sets of floats in fish dock No. I., while the remainder are situated either by the side of the channel joining one dock with another, or are inside No. II. dock.

Oysters which are sent to market from the floats are placed in a pail constructed of wire, washed in a large tub containing dock water, and packed up in bags. At the present time there seems to be a rather extensive and increasing trade at Grimsby in "canned" oysters, for use as sauce. The method of preparing these is as follows:—The oysters are taken from the floats and washed as above described; they are then opened, the shells cast aside, and the "fish," with their natural "liquor," placed in a pail; from this pail they are canned with their liquor and sent to market. This procedure has the advantage of materially reducing the bulk of the oysters, thereby curtailing the cost of transit.*

* An extensive trade in "canned" oysters is done in America. After the oysters are opened (shucked) they are placed in a flat pan with a perforated bottom, where they are drained of their accompanying liquor. They are then well washed and packed in wooden boxes or tin cans. See *Oyster Industries in the United States*, by Lieut. P. De Broca. Reports of United States Fish Commission, 1873-75.

The Grimsby and Cleethorpes Sewer Outfalls.

Grimsby, at the last census, 1891, had a population of 51,934, but since that date it has very considerably increased, and at the present time its population is computed at not less than 60,000. The excreta, liquid and solid, of Grimsby is in the main disposed of into boxes or pails, which receptacles are placed in outhouses. The slop and storm water, together with the contents of a few, but increasing number, of water-closets, passes into the sewers.

There are two sewer outfalls at Grimsby, one to the west and the other on the east of the harbour mouth. The sewer to the west, the Pyewipe sewer, takes the sewage from south and south-west Grimsby (containing a population as estimated by the borough engineer of 11,000. This sewer, which is provided with a half-tide flap, discharges at about high-water mark, into the Heycroft drain, a channel draining the fens thereabouts, which, winding riverwards across the foreshore, enters the Humber, at ordinary low-water mark, on a line with the entrance to the harbour, and about two-thirds of a mile distant from it. During about the last half of the flood tide and the first half of the ebb the sewage is dammed back in the sewer.

The other sewer which may be regarded as the Grimsby main sewer, discharges near the Fish Dock at about high-water mark. Like the other sewer, it is furnished with a flap automatically closing at near half-tide. The sewage from this outfall has excavated a deep channel in the sand, and at low-water mark enters the Humber about one third of a mile from the gates of the Fish Dock. During such time as the tidal flap is closed the sewage is prevented by means of pen-stocks from being forced back into the town sewers, and is in the meantime retained in a tank sewer near the outfall. Near high-water mark there is a small fen drain discharging its contents into the same channel as that into which the sewer discharges.

The Cleethorpes with Thrunscoe Outfalls.

Excrement, both liquid and solid, is chiefly disposed of at Cleethorpes by means of movable receptacles, but there is an increasing number of water-closets. There are two sewer outfalls, and, as at Grimsby, they are situated one to the west the other to the east of the town. The sewer which takes the sewage from the western part of the district, and serves for a population of about 3,000, discharges just above low-water mark, in the position shown on the map, about one mile and a half above the nearest Cleethorpes oyster layings. It is fitted with a tidal valve to prevent the entrance of sea-water on the rising tide; the tidal flap is closed and opened at about half tide. The eastern main sewer, which takes the drainage from a population of some 4,500, and which has only been recently constructed, discharges about three quarters of a mile to the south-west of the oyster layings, in the position indicated. The sewage emerging from this outfall is in large part deprived of its solids by settlement in sewage tanks situated some 3,500 feet from the outfall. Like the other, this outfall is closed and opened shortly after half tide by means of a tidal flap.

As to risk of sewage contamination incurred by the Cleethorpes oyster layings, it has to be borne in mind that the sewers are not discharging for about the first half of the ebb, and that to the west of the layings there exists a sand bank, which "dries" at early ebb and is locally said to fend off the ebbing tide towards mid-stream, and away from the layings, along with sewage matters which may be present in the waters of the Humber after a journey of from $1\frac{1}{2}$ to 3 miles from the Grimsby and West

Cleethorpes sewer outfalls. However this may be, regard must also be had to the chance of contamination of these layings by sewage discharged on the last of the ebb passing over the layings.

In respect to the East Cleethorpes sewer outfall, oysters on the layings would appear to incur little risk of contamination during ebb of the tide. As regards flood tide, this may be thought of as involving risk of contamination of the oysters, even if all proper regard be had to considerations of current.*

As regards the Risks of Dangerous Contamination to Oysters Stored in the Fish Dock Floats.

As reference to the map will show, the main sewer outfall at Grimsby discharges itself into the Humber at low-water mark, about one third of a mile distant from the Fish Dock gates. This fact has raised question whether sewage may not be liable to be washed back towards the channel leading to the dock gates, and thus, when the gates are open, into the fish docks. Having regard to the topographical relation of the sewer outfalls and the dock gates, there would seem to be serious risk that under certain conditions this might happen, more especially seeing that the sewer in question continues to discharge for some time during the flood tide, and that the pier forming the seaward boundary to the entrance leading to the dock gates is constructed, not of solid masonry, but of wood, through the interstices of which water can find its way. On the other hand it has to be noted that any sewage brought into the vicinity of the dock gates would be enormously diluted before it entered the docks, inasmuch as the gates are only opened about two hours before high water. But whatever the risk of contamination of oysters on the floats owing to the foulment of the dock waters by sewage entering from the Estuary, such risk is quite independent of conditions belonging to the docks themselves. These other conditions are, in fact, such as to render the docks an utterly unsuitable locality for the storage of a food supply. For considerable periods of time (measured by hours) these docks form what is practically a closed pool of water containing numerous fishing craft, both of the smack and steam trawler class; in other words, it is often a pond 23 acres in extent, containing movable habitations which vary from a few at one time to hundreds at another, each with its own drain. No doubt the crews soon after their arrival in port leave for their homes; but, nevertheless, a considerable time is spent on board by the crews, in discharging cargo, in putting straight on arrival, and in preparing for departure, &c.† In addition to opportunity of fouling of the dock waters in the above way, there is, as has been pointed out, a long stretch of pier abutting upon both docks where fish are unloaded and packed. The washings from these piers, which consist in large part of fish débris, mixed with coal dust and the meltings of ice, drain away through

* It may perhaps be well to give here the account of the tidal currents at the mouth of the Humber as recorded in the Nautical Almanac for 1896. During the first three-quarters of an hour of the flood the tide passes strongly across the mouth of the Humber down the North Sea. The tidal water next enters the river directly towards the Lincolnshire coast in a direction W.S.W. As the water passes up the Humber, the tide sets to N.W. The water on the northern portion of the Bull bank running north-west, while that southward of the Bull bank runs directly north.

† As far as possible, efforts are made to induce the crews to go ashore to certain lavatories to relieve nature's calls, but in these matters it is not uncommon for necessity to disregard rules and regulations.

MAP TO SHOW POSITIONS OF OYSTER LAYINGS AT CLEETHORPES AND OF STORAGE FLOATS IN GRIMSBY FISH DOCKS. Map No 10





holes in the pier into the dock waters beneath. In appearance, the waters of the fish dock are, after a busy period, dirty in a high degree, and on the surface is floating débris of every description. Near one of the "floats" a urinal used by fishermen emptied itself within the dock at the time of my visit.

In a word, the Grimsby fish docks must be pronounced as an altogether improper place for the storage of oysters; and the fact that certain bacteriological analyses of dock water which the Town Council of Grimsby have procured, failed to show the presence in it of the bacillus of typhoid fever, cannot be regarded as in any material respect doing away with the fact that oysters are now stored there under very filthy and objectional conditions.

THE BUDLE BAY OYSTER POND.

For some years past experimental procedures have been adopted in the several branches of oyster culture, and in oyster fattening, on the southern shores of Budle Bay, Northumberland, and more than one locality hereabouts has been put under trial in this way. At the present time, however, there is but one pond in use wherein oysters of various ages and from divers sources are, or have been, placed for the purposes of storage, growth, and fattening. The pond has also been used for attempts to secure spat, the "collectors" laid down being cemented tiles, cockle shells, and other materials. It is so constructed that, even at low tide, the oysters are covered by a considerable depth of water.

The oysters from this pond are sold for consumption both locally and in distant parts; some, in former years, having been sent, I am informed, as far as London. The shores of Budle Bay are, for the most part, uninhabited, and no drains enter the water of the bay near to the ponds in question. The nearest drains are those from some 10 houses at Warren Mill, about a mile distant from the pond.

THE SKINBURNESS OYSTER PONDS. (Map, No. 11.)

Oyster ponds have existed during some three years near the village of Skinburness, Cumberland, on the southern shore of Solway Firth, in the position shown on the map. These ponds are six in number; four of them on the shore above ordinary high-water level, but in a position to be covered at spring tides; the other two, situated lower down on the foreshore, are covered at every tide. The ponds are well constructed, and are fed by sluices in the usual manner.

Oysters—for the most part American and French—are deposited in these ponds for the purpose of storage and fattening; they do not, I am informed, grow well here. During the winter months the upper ponds only are used, as they allow a greater depth of water to be kept over them at low tide than is the case with the other ponds; this circumstance, together with their freedom from winter freshets, reduces the risks of death among the oysters from frost. There are no drains near the ponds. The hotel in the village of Skinburness, some three-quarters of a mile distant from the ponds, is, according to information received from the Medical Officer of Health, the only dwelling hereabouts drained to the rivulet which flows in proximity to the ponds.

WHITEHAVEN.

At Whitehaven there are no oyster layings or storage ponds, but deep-sea oysters brought in from time to time by the trawlers are disposed of to local customers. I was informed by the Chief Officer of Customs at Whitehaven that the following number of oysters had been received here during the months below mentioned:—

October 1895	-	"	-	2,600 oysters.
November „	-	"	-	3,200 „
December „	-	"	-	1,600 „

THE FLEETWOOD OYSTER LAYINGS. (Map No. 12.)

These layings are situated in the River Wyre, nearly opposite to the town of Fleetwood. There are, in all, three separate layings, the position of which is approximately shown on the map; the more important laying is the southern one, namely, that situated at Arne Hill, near Barnaby's Sand. The oysters laid down here are for

Map N^o 11.

[illegible]







the most part imported to Liverpool from America and sent round to Fleetwood by steamer. They are laid down, as a rule, in the month of April, or thereabouts, and efforts are made to get rid of them by August in each year, as after that they are said to deteriorate in quality. When required for market, the oysters are despatched in bags to many of the large Yorkshire and Lancashire towns. These layings therefore may, in the main, be regarded as storehouses for American oysters during such time as the hot weather precludes the importation of American oysters from abroad.

The chief pollution of the River Wyre, from the point of view now under consideration, is that brought about by Fleetwood, a town which at the last census possessed a population of 9,274. The sewage of this town enters the harbour by three separate outfalls, in positions indicated by red crosses on the map. These outfalls, I was informed, are provided with tidal flaps, to prevent the influx of sea-water; they also serve to retain the sewage while they are shut. The outfalls in question are so situated that the sewage discharged would, at low water, be cut off from the main channel by a sandbank, and there would, it appears to me, be little, if any, danger to the oysters. At other periods of the tide, they are not thus protected, but the sewage is then in a state of considerable dilution. Elsewhere the amount of sewage entering the waters of the Wyre is but small, and for the most part enters by means of different affluents; it comes from small townships such as Garstang, Great Eccleston, Thornton, and Poulton. Upon the whole the oyster layings near Fleetwood may be regarded as little liable to the risk of dangerous pollution by sewage.*

THE MENAI STRAITS OYSTER LAYINGS. (Map, No. 13-13A.)

In what is now the Western Sea Fisheries District there were, in times gone by, extensive natural oyster beds. From a very interesting report by Dr. Philip White, lecturer on Zoology at University College, North Wales, and director of the Puffin Island Biological Station, it appears that some 40 years ago these beds were sufficiently remunerative to be invaded by oyster dredgers from Essex and the Channel Islands. As a result general overdredging took place; and not only were the parent oysters taken, but brood from these beds was sent to England and France. The principal seats in those days of the oyster industry appear to have been Cardigan, Carnarvon, and Redwharf Bays, the Menai Straits, and Ogwen River.

At the present time, the oyster industry in the Menai Straits consists in the relaying of foreign oysters, chiefly American, in localities which in former years were used for the laying down of oysters dredged up in the district.

There are now four separate layings, or sets of layings, in the Menai Straits, and in the description which is to follow, they will be taken in order from the Menai Bridge eastward towards and beyond Beaumaris.

The Menai Bridge Layings.

The layings nearest to Menai Suspension Bridge are situated on the foreshore of the mainland. They commence a short distance eastward

* In the bed of the River Wyre are somewhat extensive mussel layings, and there seems to be some doubt whether the waste from certain alkali works may not be prejudicially affecting the growth of mussels in the vicinity of the works. The matter is, I understand, now under investigation.

of the bridge, and terminate just beyond the house known as Bodlondeb. (See Map 13, and Chart 13A.)

The foreshore hereabouts has a somewhat steep slope to the bed of the straits, and is of a stony character; but a certain area near low-water mark has been cleared for the laying down of oysters. For the most part American oysters are laid down, but at the time of my visit several barrels of French oysters had just arrived by steamboat and been deposited overboard on the layings. As a rule, all the oysters are, I am informed, removed from these layings by the end of August.

Between the western end of the layings and the Menai Suspension Bridge is a small house drain discharging sewage near high-water mark, and towards the eastern end of the layings and on to the foreshore immediately above them, there discharges a land water stream, not shown in the map, which receives, a few yards prior to its discharge, the sewage from a house near. Between the eastern limit of the layings and the "George Hotel" there discharges, above low-water level, the sewage from the hotel, and immediately westward of the "George Hotel" is a small drain, which also discharges some sewage. My information in regard to these drains is derived in part from personal observation, and in part from Dr. Fraser, Medical Officer of Health to the district, and from Mr. Jones, Fishery Inspector to the Western Sea Fisheries District.

The Coradygut Layings.

These layings lie about a mile from the Menai Bridge layings; they are situated on the foreshore off the cottage of Coradygut, and extend away to low-water mark. There are, in all, six separate layings marked off from one another; but the two seaward ones, I was informed by the caretaker, have alone been lately used. At the time of my visit, some American oysters recently arrived from Liverpool had been deposited on the lowest laying. Some 200 yards westward of these layings there discharges at low-water mark the Upper Bangor sewer, which, I was told at the surveyor's office, serves some 250 houses. The danger to the oyster beds is increased by the fact that in this sewer, as it traverses the foreshore, are sundry vent-holes, from which, I was told by the caretaker, storm sewage at intervals issues. One of these vent-holes is situated near the upper layings, and another near the western side of the layings.

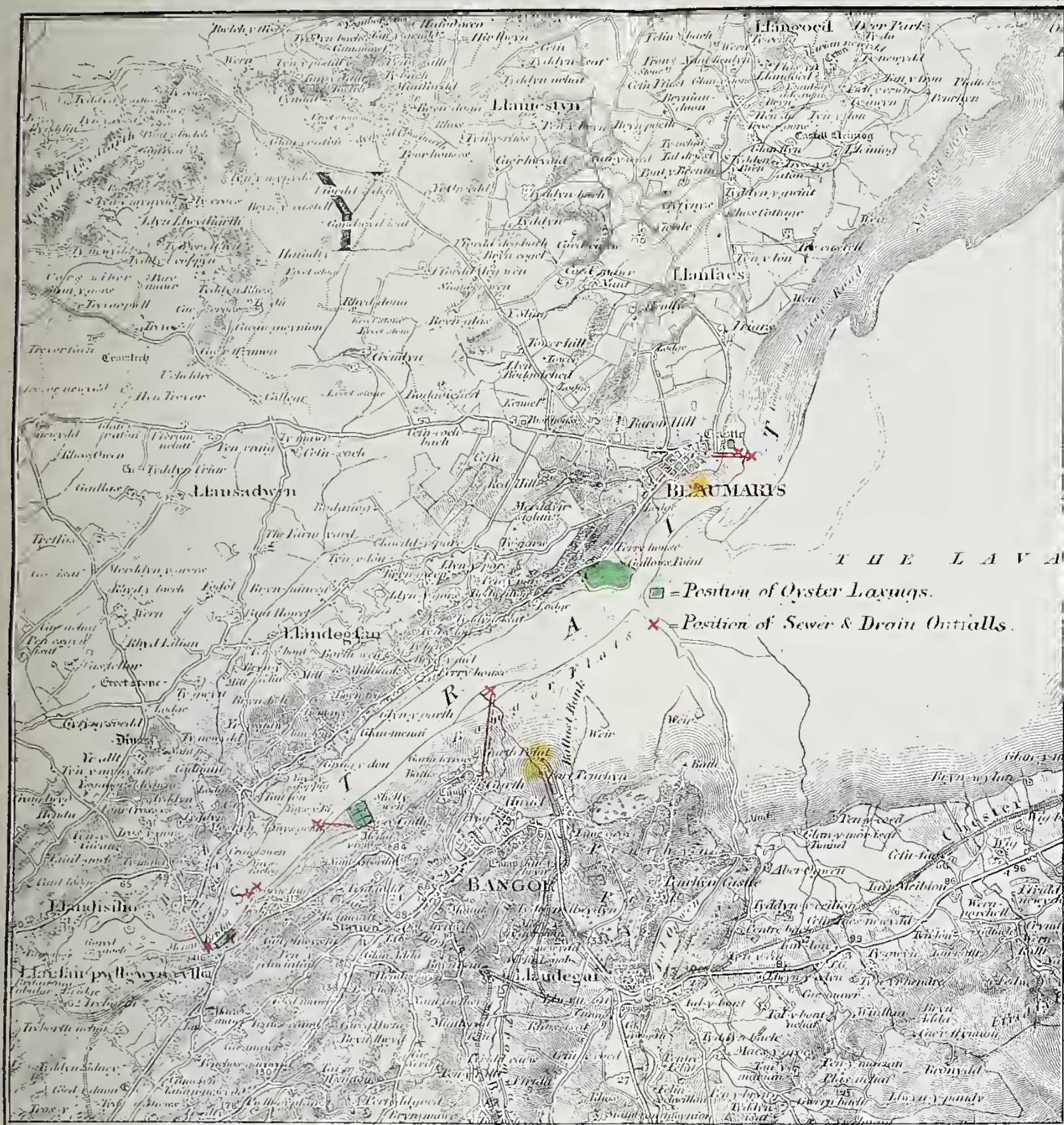
The Gallows Point Oyster Layings.

The position of these layings is indicated on the map. Large numbers of imported oysters are laid down here in the spring of the year. There are no sewers near to these layings, and, having regard to the set of the tides hereabouts, as well as to the vast body of water into which sewage in other parts of the Straits is received, the layings would not seem to be subject to any appreciable risk.

"The Green" Oyster Layings, Beaumaris.

These are the most easterly layings of the Menai Straits, and occupy a position on the foreshore, just below the public baths, as shown on the map. As in the case of the other layings in the Straits, American oysters are those which are chiefly laid down.

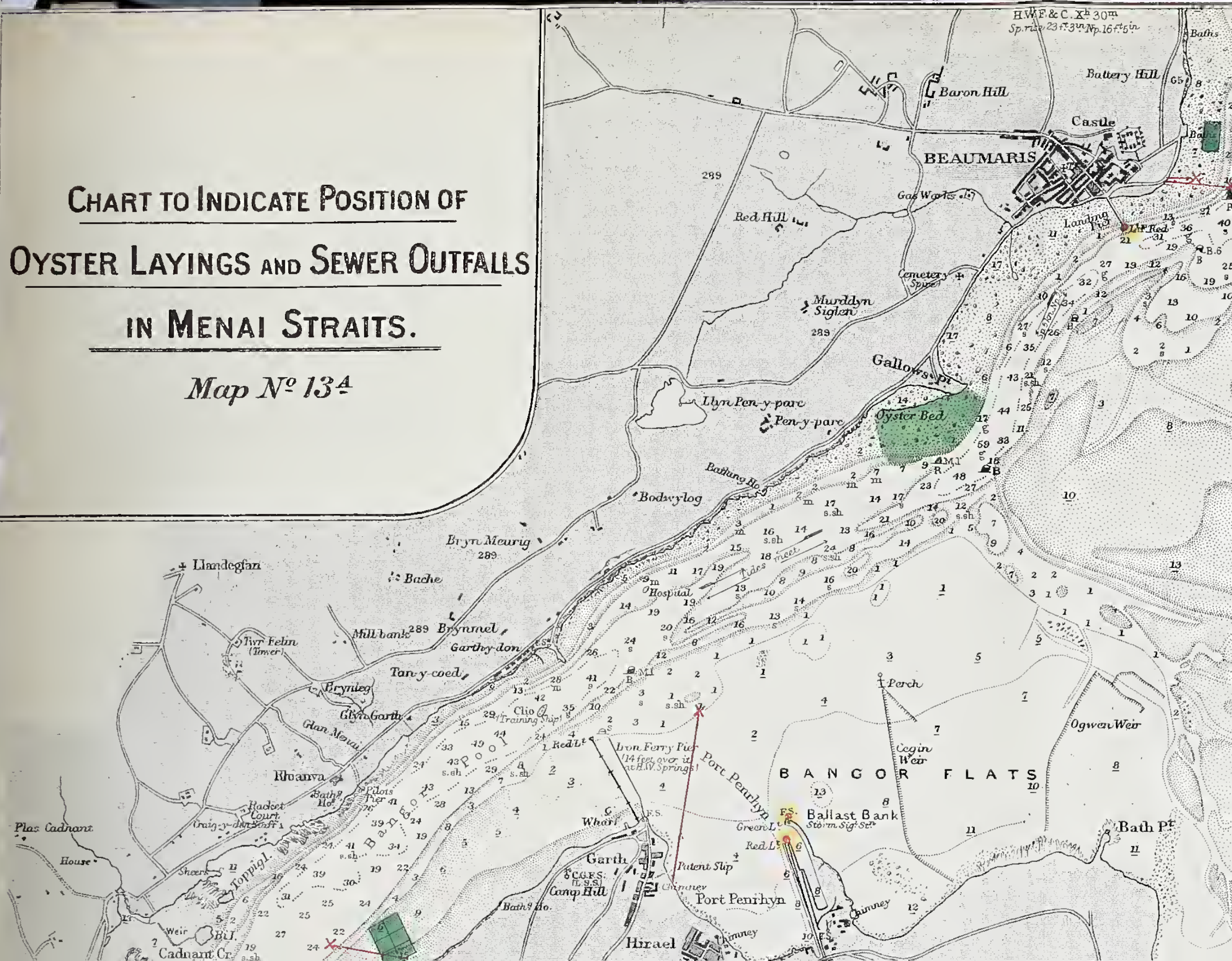
CHART TO INDICATE POSITIONS OF OYSTER LAYINGS AND SEWER OUTFALLS IN MENAI STRAITS. *Map N^o 13.*



LDOUT BLA

IN MENAI STRAITS.

Map N^o 13^A



The main sewer of Beaumaris (population 2,202) discharges below low-water mark, in a position near to the more easterly of the red crosses upon the map while hereabouts, nearer high-water mark there is a small overflow pipe from this sewer. The main outfall is some 200 yards from that part of the shore used, at the time of my visit, for oyster layings, and it is contended that during the ebb tide, the only period when the layings might be in danger of pollution, the sewage is carried directly into the channel and away from the layings.

Even if this view were accepted as correct, it would seem, that under certain conditions of tide and wind, sewage would, under existing circumstances, stand a good chance of being carried to these layings.

An examination of the chart will serve to indicate that the sewage entering the waters of Menai Straits, must, even at low tide, undergo great dilution, inasmuch as the depth is in all parts very considerable. At high tide the dilution of the sewage by sea water must be very great indeed. The waters from the western and from the eastern entries to the Straits meet and divide near Port Penrhyn, and this fact must be held in view in estimating the course taken by sewage matter in the channel. It cannot be denied, however, that in the Menai Straits, all the layings except those at Gallows Point are in suspicious topographical relation-ship to sewer and drain outfalls.

MILFORD HAVEN SEA FISHERIES DISTRICT.

In this district there are, I am informed, no oyster layings or storage ponds, but on natural beds in the waters of Milford Haven and in the River Dauceddau, which flows into it, oysters are still dredged for and sold in the neighbourhood. In former years, oysters hereabouts were extremely plentiful. Mr. Davis George, the Clerk to the Sea Fisheries Committee, tells me that within his memory they have been sold at 6*d.* per 100; in times more remote 4*d.* per 100 appears to have been not an unusual price. The chief centre of this oyster fishery is, at the present time, the village of Langum, situated on the banks of the Dauceddau, about seven miles north-east of Pembroke Dock. Some 30 or 40 boats belonging to the village are engaged in the oyster fishery, and each boat is, as a rule, "manned" by two women and one man. The oysters which are dredged up are sold chiefly in the towns near, such as Pembroke Dock, Haverfordwest, Old Milford, &c., while some of them, at times, reach the large English towns. In the neighbourhood of Langum, donkeys with paniers are largely used in hawking the oysters for sale; for the rest, women carry their baskets on their backs. Dredging operations extend, I am informed by Mr. Edward Morgan of Langum, from just seaward of that village down to, and sometimes beyond, the town of Old Milford. The oysters are, as a rule, sold as soon as dredged; they are not stored. In the event of there being delay in disposing of them, they are laid down for a short period on the foreshore; this, however, is, I understand, a very uncommon occurrence.

The river is of great depth, even at low tide, and consequently heavy dredges are in use. But little sewage enters the river itself; Haverfordwest—a town having at the last census a population of 6,179, and which discharges its sewage by numerous outlets into the estuary—being distant some nine or ten miles from the nearest oyster grounds. Further seaward, into the waters of Milford Haven or into "pills" connected with it, there is discharged by separate outlets the sewage of Pembroke Dock and of Pembroke (population in 1891, 14,978), of Neyland, and of Old Milford (Milford Haven, population 4,079).

Having regard to the volume of water hereabouts there would appear to be but little risk of dangerous pollution of the oysters from these sources.

TENBY.

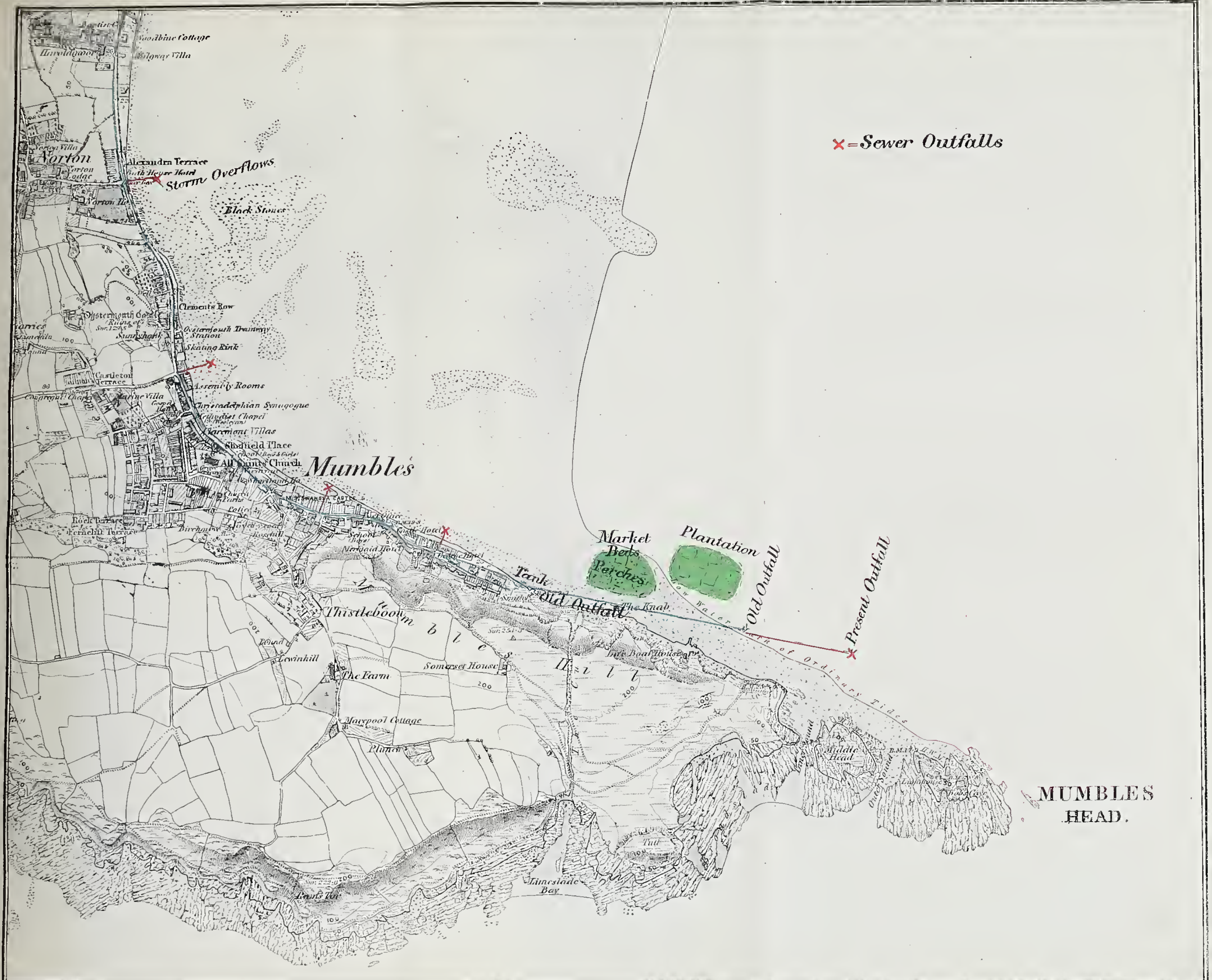
Years ago, many oysters were dredged up at sea in the neighbourhood of Tenby and exported thence to various places. Now there are but two or three Tenby boats which dredge for oysters, and those obtained by them are disposed of locally. The deep-sea oyster beds off Caldy Island and Stackpool Head are, as a rule, fished by the Mumbles fishermen, who take their catch back to the Mumbles storage beds. Formerly, oysters caught off Tenby were stored in the harbour here, until wanted, but this practice has long since ceased.

THE MUMBLES OYSTER FISHERY. (Map, No. 14.)

There are at various points along the Bristol Channel, such, for instance, as off the Mumbles, Swansea Bay, Caldy Island, and Stackpool Head, natural oyster beds, which, during the season allowed by law, are dredged over with heavy iron dredges, weighing some 96 lbs., by the fishermen having their head-quarters at Mumbles. The Mumbles fishery was at one time an exceedingly flourishing industry, some 200 or more boats having been employed in it. Some idea of the extent of this fishery may be gathered from a report made by Mr. Hall to the Board of Trade in 1876, wherein it is stated that, in 1873, the take of oysters amounted to 9,050,000; in 1874 to 6,600,000; and in 1875 to 3,810,000. This diminution in the take Mr. Hall regarded as due in the main to overdredging. Within recent years, the fishery has very markedly declined, and at the present time there are but some 25 boats engaged in it. In 1894-5, 22 annual and three short period licences to dredge were issued, and the quantity of oysters taken is stated to have been 600,000. The oysters dredged up are brought back by the dredgermen to the Mumbles, and while awaiting market are deposited in what are known as the "perches" (see Map No. 14), *i.e.*, portions of the foreshore divided off from one another by stones into several holdings, which are for the most part uncovered at ordinary low tides. It is found that the deposition of oysters, if only for a few days, on these "perches," tends very materially to improve their condition. Such oysters as are not of marketable size are laid down, hard by, on what are known as the "plantations," the position of which is shown on the map. These "plantations" or "layings" are, unlike the "perches," only uncovered at or near extreme low water of spring tides. The "brood" or immature oysters laid down there are, when ready for market, removed to the "perches," a process which seems to free the oysters of any mud which may have become attached to them on the "plantations." I was, informed that no oysters are sent to market direct from the "plantations."

The supervision of the Mumbles fishery is, by the provisions of the Swansea Fishery Order, 1892, vested in the hands of the Fisheries Committee of the Glamorganshire Sea Fisheries District. By the Order in question it is enacted that no dredging or fishing for oysters shall take place within the fishery limits, *i.e.*, from Melwick Light Vessel to Skyer Point, during May, June, July, or August—nor within certain defined portions of the fishery from March to November inclusive.

The sewage of Oystermouth (population in 1891, 3,675) was, until quite recently, discharged at the old outlet shown upon the map. Since



X = Sewer Outfalls

MUMBLES
HEAD.



my first visit however the sewer in question has been very wisely carried seaward by some 200 yards, and by this means the danger of sewage pollution, which obviously threatened the "plantations" formerly, has been materially reduced. Sewage is stated to be discharged at all states of the tide, but it appears that during the greater part of both the ebb and flow of the tide, the currents near the sewer outlet are, so far as I can ascertain, such as to take the sewage away from the oyster layings. It would, however, certainly seem that, during some states of tide and wind, there may be risk of contamination to the oysters on the "plantations," and possibly, under exceptional conditions, to those on the "perches."* As, however, there is already in existence a sewage tank in the course of the Oystermouth sewer, it is practicable to liberate the sewage only at such times as it is likely, by the direction of the currents, to be carried out to sea. Along the foreshore, in positions shown on the map, are sundry storm outfalls on the Oystermouth sewer, from which dilute sewage may on occasion find exit. The sewage of Swansea finds its way into Swansea Bay, some 3 or 4 miles distant from the layings. The amount of dilution which Swansea sewage must undergo in crossing the bay, if as a matter of fact it can cross it, must needs be so great as to render a consideration of it in relation to the Mumbles oyster beds unnecessary.

THE HELFORD RIVER OYSTER FISHERY. (Map, No. 15.)

The Helford river, which is situated on the coast of Cornwall, a little west of Falmouth, yields a prolific supply of oysters of native growth. The fishery here has for many years been worked by a local resident. The most productive portion of it, which is coloured green on Map No. 15, extends from just below Merthen Quay to near Helford Ferry, embracing parts of Polwheverral and Porth Navas Creeks. The oysters are dredged up from those parts of the estuary which have been indicated, and are deposited, until a cargo has been procured, in storage ponds situated in Polwheverral Creek in the position represented by a blue dot on the map. When a sufficient number of oysters has been procured they are sent by sea to the owner's store-house at Plymouth, from which they are despatched as required to market. The Helford river and the "creeks" abutting upon it traverse an almost unpopulated, and for the most part thickly wooded, country; there are no sewers entering it hereabouts. Similarly, the storage ponds into which the oysters are placed to await despatch to Plymouth are free from risks of contamination; indeed, the estuary appeared to me, from the view point of this inquiry, to be well fitted for the preparation of oysters for market.

FALMOUTH OYSTER FISHERY. (Map, No. 16.)

The oyster fishery in Falmouth harbour is by the provisions of the Oyster and Mussels Fishery Order Confirmation Act, 1877, under the control of the Corporation of Falmouth, and for the purpose of this report the limits of the Corporation's jurisdiction in the matter of oyster and mussel fishing may be taken to extend over the whole harbour below ordinary low-water mark, as far inland as an imaginary line drawn from Messack Point to Penarrow Point. The jurisdiction of the Corporation extends also up the Penrhyn river as far as Boyer's Cellars,

* It is stated locally that, even when the current sets in along the Mumbles shore, it sweeps out again into the bay before the "perches" are reached.

but not up the other creeks abutting upon the Carrick Roads, such as St. Just Creek and St. Mawes Creek (the Porthcuel river), while in Penrhyn river the power of the Corporation is apparently curtailed by vested interests. Over the whole of the area indicated above, dredging for oysters below low-water mark may take place during such months of the year (at present October to March), as are appointed by the Corporation, subject to the dredgermen obtaining a license to dredge and to their observance of certain regulations as regards the taking of oysters under a specified size. It is further enacted by the Act above referred to that portions of the harbour may be closed entirely against oyster dredging for not more than three years, provided that only a third or less of the grounds are closed at one time; but any such prohibition may be altered or repealed by the Board of Trade. Acting upon the powers thus conferred upon them the Corporation recently closed a portion of the grounds known as the "velt," and I am given to understand that this procedure has been attended by considerable success. The fishery-bailiff of the Corporation stated to me that before this portion was closed it was difficult for a rowing boat to obtain more than 50 oysters in a day, but that since the ground has been reopened, as many as 5,000 can easily be procured. I learn from the Tenth Annual Report of the Inspectors of Sea Fisheries that during 1894-5, 64 boats were licensed to dredge for oysters in the waters of this fishery. Over a considerable portion of Falmouth Harbour the oysters, when dredged up, frequently present a diffused green coloration over parts or even the whole of their substance. The greenness of these Falmouth oysters persists all the year round, and, whatever it may be due to, it is found that in practice the oysters are in this condition quite unsaleable in this country; and, hence, all oysters dredged up in the Corporation grounds are either laid down by the dredgermen in layings in the creeks abutting upon the harbour, such as Penrhyn, St. Mawes, and St. Just, or are sold to oyster merchants having layings in other parts of the country.

Oysters dredged up directly from the beds are known as "fresh catch." "Fresh catch" laid down for some six months, or so, in creeks abutting on the harbour is known as "seconds"; and oysters that have been thus laid down for a year are known as "over years" or "natives." As, therefore, oysters dredged up from the Carrick Roads or thereabouts are laid down for at least six months in the waters of the "creeks" abutting upon the Roads, it is to these layings that attention will now be given.

The Oyster Layings in St. Mawes Creek. (Porthcuel River.)

St. Mawes Creek is situated to the east of the Carrick Roads, and extends inland from the village of St. Mawes for a considerable distance (see Map 16). In St. Mawes Harbour itself, which is situated immediately opposite the village of that name, there are no oysters laid down; but eastward of Amsterdam Point, to the south, they extend up both sides of the Porthcuel river to the commencement of Polingey Creek, as indicated in green on the map—a distance in all of about two miles. There are along this river certain areas where oysters are not laid down, as, for instance, at mooring stations and at ferries. The oysters taken from these layings are, I am informed, sent direct to market, inasmuch as in this creek they rapidly lose the green colouration which they possess when freshly dredged up from the Roads; they are packed up on board the boats or in neighbouring hamlets, and despatched by steamer to Falmouth.

MAP TO INDICATE POSITION OF OYSTER BEDS & STORAGE PONDS IN THE
HELFOED RIVER (MAP N° 15.)



St. Just Creek.

The layings in this creek extend only for a short distance, and arrangements are made by means of low stone partitions to keep the oysters covered with water at all states of the tide; an arrangement necessitated by virtue of the long periods for which the oysters would otherwise be left exposed at or near low water.

The Oyster Layings in the Penrhyn River.

The oyster layings in this river extend from just westward of an imaginary line drawn from Flushing New Quay to the Greenbank Quay, as far up the river as is indicated by green colouration on the accompanying map (No. 16), *i.e.*, to within about one-fourth of a mile of Penrhyn Quay. There are at places certain areas where no oysters are laid down, but the layings may be generally taken as extending up both sides of the river between the points indicated. On the foreshore of the river at Flushing are numerous layings belonging to fishermen and others, each man despatching his own stock to market or getting rid of them to larger buyers. There are, too, hereabouts, on the northern side of the river, certain layings which are used for wintering the foreign stock of a London firm, and also for the growth and fattening of French oysters. These oysters are sent down from more eastern waters in October and November, and returned in March or April. As a rule attempts are made to sell the French oysters direct from these northern waters before the cold weather sets in; when that has occurred the trade is carried on from the Flushing beds. On the Falmouth side of the Penrhyn river the layings are less numerous, but each is of greater extent; indeed, from near the Greenbank Hotel to near Boyer's Cellars the ground is held by two large merchants. One of them does a large trade in oysters dredged up from the Carrick Roads; while the other lays down much French produce. All oysters from the Penrhyn river are, as a rule, sent direct to market.

Sewage Disposal in Relation to the above several Oyster Layings.

The sewage of Falmouth (population 11,632) is partly treated and partly untreated, the greater portion being treated. The treatment consists of the addition of precipitants (sulphate of alumina and lime), storage in tanks, and a rough filtration through vertical screens, the interval between which is filled with coarse stone. Of the "treated sewage" the effluent is discharged into the inner harbour at Market Strand and near the Bar, while the sludge is carried out in barges to sea. The "untreated" sewage finds its way into the inner harbour mainly by two outfalls; one near the Custom House, where the sewage of some 25 houses empties itself, the other about 100 yards eastward of the Greenbank Quay, where the sewage of Penwerris, some 116 houses, discharges. In addition, 170 houses, or thereabouts, which are too low to be drained into the common sewer, discharge independently upon the foreshore at different points. Eastward of the Greenbank Quay are sundry drains or sewers, from a few houses near, discharging themselves on the foreshore in positions indicated upon the map.*

At Flushing, where there are, I am told, but few waterclosets, a few slop-water drains and sewers discharge near the mouth of the river. Of

* For information in regard to the Falmouth outlets I am indebted to Mr. Tressider, the Borough Surveyor, who was good enough to accompany me on my inspection.

the latter the most important is that near the "Seven Stars" Inn. Much vegetable and other heterogeneous refuse is also deposited on this foreshore.

At Penrhyn, in a position marked by a red cross, the main sewer of Penrhyn, population 3,256, discharges itself, and at other places along the quay other small sewers discharge.

At St. Mawes the drainage of the village is discharged by various openings on to the foreshore.

The Liability of the Falmouth Oyster Beds and Oyster Layings to Sewage Pollution.

In the Carrick Roads and thereabouts the oyster beds must certainly be regarded as free from serious risks of sewage pollution; and, further, it has to be borne in mind that, owing to the greenness and general want of condition to which oysters dredged up from here are liable, they are not despatched direct to market.

As to the oyster layings in the Penrhyn river, it is to be regretted that a similar statement cannot be made. It will be seen from the map that the layings extend to within a quarter of a mile of Penrhyn Quay, where the crude sewage of the town of Penrhyn is discharged. At low tide the river hereabouts is a mere rivulet, and not navigable by the smallest rowing boats; indeed, a considerable part of the water passing down the bed of the stream when the tide is out must be composed of Penrhyn sewage, and this, as it finds its way seaward, cannot fail to pass over some of the oyster layings. It may, too, be noted that Dr. Blamey, Medical Officer of Health for the Borough of Penrhyn, informed me that no less than 95 cases of enteric fever were notified to him during 1894.

At Flushing there are, as has been already stated, sundry slop-water drains and sewers discharging on to the foreshore. In some instances oysters are laid down within about 6 yards of the quay wall, and within some 30 yards of the main outfall are extensive oyster layings. Obviously all the layings hereabouts are not exposed in the same degree to risks of contamination, those farthest removed from the quay being much less liable to pollution. On the opposite side of the river near to the layings thereabouts, between Boyer's Cellars and the Greenbank Quay, are several small drain outlets, and at the quay itself, another. About 100 yards seaward of the Greenbank Quay is the Penweris outfall already referred to.

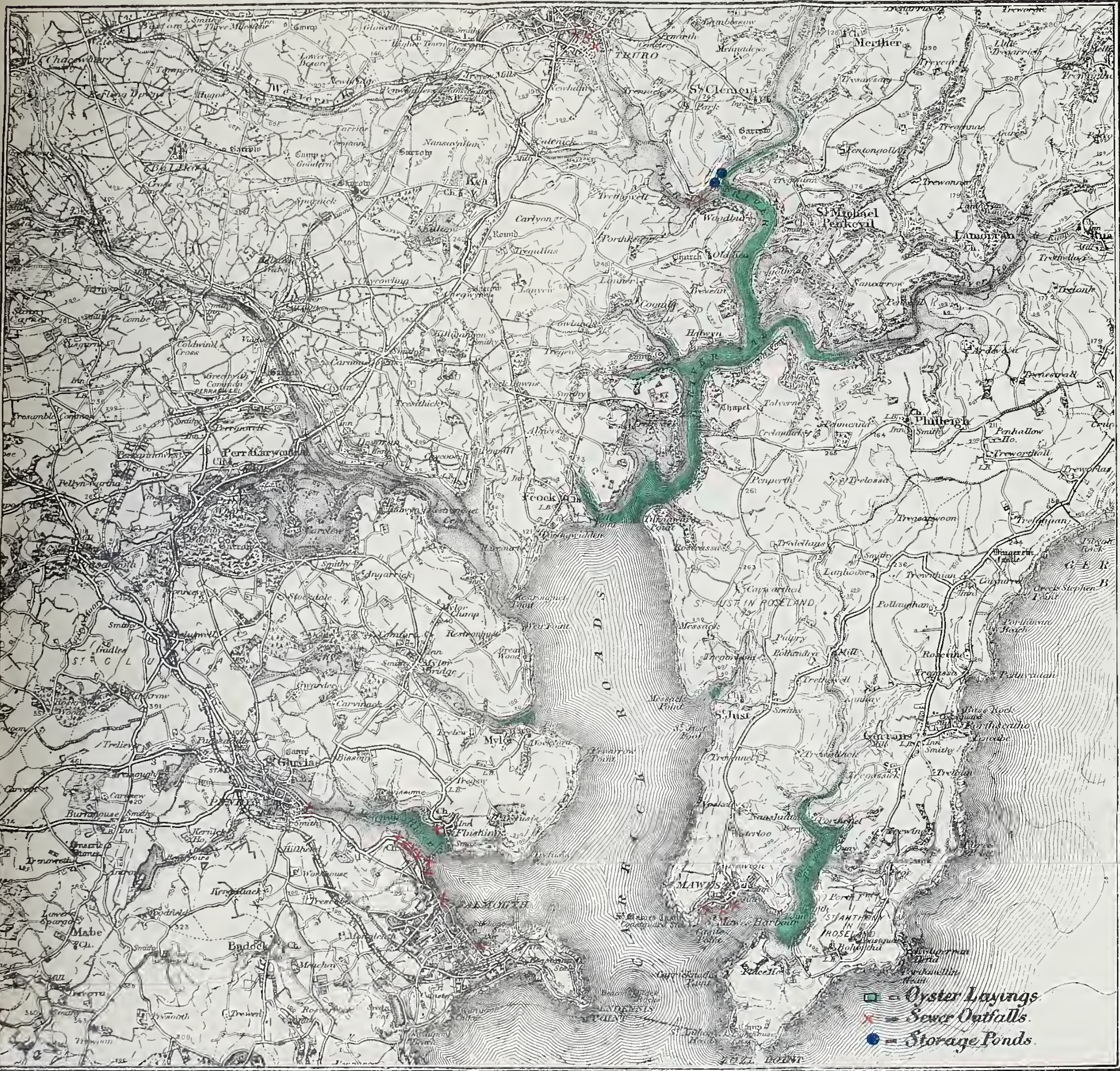
Having regard to all these facts, Penrhyn river cannot be viewed in the light of a safe locality for preparing oysters for market; in fact, oysters near to Penrhyn must be regarded as occupying a dangerous position. The whole length of the Penrhyn river from the Penrhyn Quay to the Greenbank Quay does not exceed $1\frac{1}{2}$ miles.

With reference to St. Mawes Creek, it has to be observed that the nearest layings are situated at a point above and rather over half a mile from the village, and are, indeed, separated from it by the whole width of St. Mawes Harbour. The amount of dilution which must take place before any sewage can cross the river is so great as to render the layings in this creek and river but little liable to pollution. There is also no reason to regard the layings in St. Just Creek as liable to contamination.

THE TRURO OYSTER FISHERY. (Map, No. 16.)

The oyster fishery in the Truro river and the northern portion of the Carrick Roads is vested, by the provisions of the Oyster and Mussel

MAP TO INDICATE POSITION OF OYSTER LAYINGS & SEWER OUTFALLS IN CONNECTION WITH THE FALMOUTH AND TRURO OYSTER FISHERIES (MAP N°16.)



Fisheries Order Confirmation Act, 1876, in the Corporation of Truro. The limits of the fishery (see Map 16) extend from a line joining Messack and Penarrow Points, to as far up the Truro river as a line joining Victoria Point with the point known as Sunset.

Over the area embraced by these limits dredging below ordinary low-tide mark may take place after procuring a dredging license from the Corporation, and subject to the observance of the byelaws in force.* To convey some idea as to the extent of this fishery, it may suffice to observe that during 1894-5 no fewer than 184 boats were licensed to dredge for oysters, and that the number of oysters taken was 3,680,000.

Referring now to the practice in vogue in this fishery, it may be stated that, as a general rule, oysters dredged from the Carrick Roads or thereabouts, or, indeed, anywhere south of King Harry's Ferry, near Trelissick (see Map 16), are not despatched direct to market, since, as likewise is the case with the oysters dredged from the Falmouth waters, they do not command a ready sale for food, owing to the greenness and general want of condition which characterises them. The laying down however of these oysters for a time in other waters suffices to render them a normal colour. Hence, in the Truro waters—as in the Falmouth waters already referred to—it is the practice to lay down the “fresh catch” for considerable periods in the creeks abutting upon the river and upon the foreshore of the river itself. It thus comes about that in creeks such as Mylor, Pill, Channel, and numerous others, which will be seen to be coloured green on the accompanying map, there are established numerous private oyster layings for the reception of oysters dredged from the Corporation waters.

The temporary deposition of oysters on the foreshore of the Carrick Roads, and of the river itself south of King Harry's Ferry, tends materially to improve their condition, but I am informed that on the foreshores indicated, they but rarely become fit for market. On, however, the foreshores above King Harry's Ferry, as well as in the creeks abutting upon the river thereabouts, the oysters improve very materially in condition, becoming plump and acquiring the proper colour for the market.

Above King Harry's Ferry the layings are very numerous, and they extend up the creeks for some distance, as well as occupying the foreshore of the river itself.

On the western side of the river are layings in Lamouth and Cowlands Creeks, and in the river itself as far north as Woodbury Point, *i.e.*, within some $2\frac{1}{2}$ miles of the Truro Quay. There is also a small laying on this side of the river nearly opposite the village of Malpas. On the eastern side of the river the layings extend from Turnaware Bar, or Point, until the village of Malpas is reached, while they also extend about a mile up the River Fal off what is marked as Borlase Wood on the map, and also at intervals for a considerable distance up the creek (Tressillian Creek), which extends to the westward of Malpas. On the foreshore of the village of Malpas are some small layings which are apparently used more for storage than fattening, while hereabouts there are also some half-dozen storage ponds excavated out of the rock on the foreshore. One of these ponds is almost immediately below the village inn, while one of the storage layings is hard by the landing stage to the same inn.

* At the present time no oysters may be taken off the ground under $2\frac{1}{4}$ inches in diameter.

Liability of the Truro Oyster Layings, &c. to Contamination by Sewage.

The sewage of Truro (population, 11,151) is, I am informed by the Borough Surveyor, discharged by numerous outfalls into one or other of the tributaries Allen and Kenwyn, which, uniting below the city, form the Truro river. At low tide the condition of both these streams, more especially in certain localities, is offensive to the senses of sight and smell. The Truro river itself from the city down to the village of Malpas is at low tide but a small and tortuous rivulet, not even navigable by an ordinary rowing boat; so that, especially in the more rainless months, a considerable portion of the stream must consist of the sewage and slop-water of Truro. It is true that no oysters are dredged up, laid down, or stored, within two miles—as the stream at low tide runs—of the town quay, and that it is not possible to trace crude sewage in the river far from the town. Nevertheless, it would seem, having regard to the large population whose sewage enters the river at Truro, and to the very small body of water with which it is diluted at low tide until after Malpas is reached, that there is no escape from the conclusion that oyster layings near Malpas, and in the upper waters of the reach below it, must be liable to contamination.

After the junction of the Truro river with the River Fal, the channel rapidly deepens, and presents, even at low water of spring tides, as much as 40 and 50 feet of water in the channel, while the banks of the river are also steep.

At Malpas there are slop-water sewers from about 20 houses, and also a privy, discharging themselves dangerously near one of the ponds and some of the small layings to which reference has already been made. The other storage ponds hereabouts are practically in the Tressillian river, and are remote from these sources of pollution. Apart, however, from the risk to which oysters on the foreshore of, and near to Malpas village, are certainly liable, and to suspicion which must attach to layings in the reach of the river immediately below Malpas, I see no reason for regarding the layings or beds of the other parts of the Truro fishery as otherwise than reasonably secure from the chances of sewage pollution. It has of course to be remembered that a very large proportion of the oysters dredged up from the grounds of the Truro Corporation are laid down, prior to being eaten, in waters in other parts of England; indeed, just before my visit, a very large number of oysters had been purchased and shipped away for this purpose. As prolific breeding grounds, there is no doubt that the waters both of the Truro and Falmouth Corporations hold very high rank.

THE FOWEY RIVER.

There is no trade in oysters done from the Fowey river at the present time, though I am informed that in years gone by there was an extensive natural oyster bed here. Oysters are, it appears, still from time to time dredged up over a certain portion of the upper reaches of the river, *i.e.*, between Wiseman's Stone and the Saw Mills—a distance of about half a mile.

I am told by Mr. E. W. Rashleigh, author of "A Brief Guide to the Edible Cornish Fishes," that there is an oyster bed in the sea off Fowey. Also another between Polkerris and Mevagissey, and that lobsters obtained from this locality are often covered with oyster spat.*

* In the Natural History Museum at South Kensington may be seen specimens of lobsters upon which are fixed numerous oysters.

Mr. Rashleigh states that about five years ago a large number of oysters was obtained at a very low spring tide from Kilvargen Rock, near Par.

In the Fowey river there are no marketable oyster layings, but at the time of my visit an oyster merchant from Falmouth had deposited—apparently as an experiment—a few oysters on the foreshore in Pont Pill, opposite Fowey. The insignificant character of the oyster industry in the Fowey river hardly seemed to call for a detailed inspection of the estuary, but it may be remarked that there is little or no sewage passing into the water of Pont Creek directly, while the chances of the sewage of Fowey entering the creek are very remote.

THE SALTASH OYSTER FISHERY.

The oyster fishery in the Rivers Tamar, Tavy, Lynher, the Hamoaze, and Plymouth Sound, was vested in the Corporation of Saltash by virtue of the provisions of Charters granted in the reigns of Elizabeth, Charles II., George III., and Victoria, each Charter confirming the privileges which were granted in the first Charter.*

The Charters gave to the Corporation of Saltash the oyster fishing in the waters bounded on the south by an imaginary line drawn from Penlee Point to the Shagstone, and extending in an inland direction as far up the River Tamar as Okelton, above Calstock, up the River Tavy to Mariston, and up the River St. Germans to St. Germans; in short, the limits of this fishery embrace Plymouth Sound and the waters abutting upon it.

It was, however, enacted by the Charters that between February the 2nd and Good Friday, the inhabitants of Saltash should have the right of dredging in the Corporation waters, subject only to the restriction of ring measurement ($2\frac{1}{2}$ inches) of the oysters obtained by them by a bailiff appointed by the Corporation. The Corporation in years gone by let their rights on lease; but the inhabitants of Saltash had, of course, still the right to dredge between the dates above-mentioned.

The fishery was in former years an important one, and large quantities of oysters were procured from it. It appears, however, that the dredging operations which have been carried out with a view to deepening the channel of the Hamoaze and other parts have had the effect of destroying some of the most productive natural beds here, and the oyster industry has in large part died out; in fact, so great was the damage wrought by these influences that the Corporation of Saltash was compensated for the loss of part of its fishery, and so much has the industry decayed that little control is now exercised by the Corporation over it, a bailiff being no longer employed; while during last season only one or two local fishermen took advantage of the privileges conferred upon them by the Charter. It seems, indeed, that there is not a ready sale for even these few oysters that are dredged up here, inasmuch as they are not in a condition ready for consumption, being liable to be affected with greenness, such as is the case with the Falmouth and Truro oysters, and to possess the disagreeable taste which distinguishes these oysters. It would appear, however, that the fishery—or what remains of it—is better fitted for breeding or growth than for fattening, and that it is desirable, therefore, to remove the oysters dredged up to other localities to prepare them for market. Such little oyster fishing as is now done is confined to

* For much of the information here given, I am indebted to Mr. Harvey, the Borough Surveyor of Saltash.

the Hamoaze, the mouth of the St. Germans river, and the River Tamar a little above and below Saltash Suspension Bridge.

It is, under the circumstances, hardly necessary to enter into a detailed account of the sewage entering the waters under the jurisdiction of the Saltash Corporation; but it may be observed that into the Hamoaze there enters the sewage of Devonport and Stonehouse, as also that from sundry war vessels and training ships located hereabouts. The untreated sewage of Saltash enters the river just near the Suspension Bridge. It is, however, right to add that any sewage entering the water of the Hamoaze and the Tamar must at once undergo enormous dilution.

DARTMOUTH.

There is, I find, no trade done in oysters from the River Dart at the present time; but I am informed that at rare intervals one or two small boats dredge for oysters near the mouth of the river, and dispose of their catch locally. There are no layings for oysters hereabouts.

BRIXHAM.

The Brixham trawlers bring in, during certain months of the year, deep-sea oysters, which they have captured, and they are at once sold by auction on the Fish Quay. In winter, when the trawlers obtain considerable numbers of oysters, they are taken from their shells and sent away, together with their liquor, in bladders, in a like manner to that in which oysters are at times despatched in tins from Grimsby.

TORQUAY.

At Torquay there are a few boats which dredge for oysters during the oyster season in and around Tor Bay, but there are no layings in this locality.

TEIGNMOUTH.

A few years ago there were some oyster layings in the River Teign belonging to a London merchant. They were situated on the eastern foreshore, a short distance above the gasworks. The laying down of oysters hereabouts has, however, now been discontinued. There are, I am told, a few small boats which dredge for oysters on the coast, and dispose of their catch forthwith in the locality.

THE EXE.

Several years ago oysters in large numbers were laid down off Lympstone, on the eastern side of the river, and there were also layings near the Warren, at the mouth of the estuary. The oysters were procured from Falmouth and elsewhere, and laid down to grow, while near the village of Lympstone were sundry storage ponds, in which oysters awaiting market were at times placed. The layings and ponds are now used for mussels, and a large industry is carried on from hereabouts in these molluscs.

THE FLEET OYSTER FISHERY, WYKE REGIS, DORSET.

Attempts at oyster fattening have been made on more than one occasion in the waters of the Fleet, which is situated immediately inside the Chesil Beach, and at the present time a considerable number of

French oysters are laid down here. These oysters even at the lowest tides are always covered with water. The sides of the Fleet are almost uninhabited, and there is but little sewage to gain access to its waters. Near the outlet of the Fleet into Portland Roads is a drain coming from the isolation hospital of the Weymouth Port Sanitary Authority. This drain outlet is, however, about three-quarters of a mile below the oyster layings, and I am informed by the Medical Officer of Health to this Authority that the excreta from patients suffering from typhoid fever and cholera are cremated and not allowed to enter the drainage system.

POOLE OYSTER FISHERIES. (Maps Nos. 17 and 17A.)

In former years an extensive oyster trade was carried on at Poole, and a large number of oysters was sent from here to the London market; oysters, too, were exported. Attempts at artificial cultivation were also made hereabouts, but apparently without much success. The prosperity of the Poole oyster fishery has much fallen off during recent years, and at the present time the industry is not a very extensive one.

The Corporation of Poole has jurisdiction in regard to oysters over the greater part of Poole Harbour, save in certain portions of the Wareham Channel, held by the Poole Oyster Company, and South Deep, which is apparently common ground. The Corporation employ a water-bailiff whose duty it is to control the fishing and to prevent oysters under certain prescribed dimensions from being taken. Licenses to dredge in the waters belonging to the Corporation are granted to fishermen on payment of certain fixed sums.

From the Ninth Annual Report of the Inspector of Sea Fisheries, it appears that in 1893-94 only seven dredging licenses were issued here. In the same year the fees and tolls amounted to 5*l.* 15*s.*, and the number of oysters taken, to 8,346, *i.e.*, 20 per cent. fewer than in 1892-93. In 1894-5 there were 33,702 oysters taken. The fishermen who hold the licenses from year to year have no storage pits; they dispose of their catch forthwith in the best market. Oysters and brood are dredged up all along the main channel, but the best portions for dredging purposes are stated to be near Saltern's Pier, Brownsea Quay, and Stone Island.

The Poole Oyster Fishery Company.

This Company in 1887 obtained from the Board of Trade a "Several" oyster and mussel Order, which was subsequently confirmed by Act of Parliament. The area of the Company's grounds at Poole is about 170 acres, and extends along the Wareham Channel from a straight line joining the western extremity of Hamworthy Station, on the northern bank of the estuary, with the westernmost point of Green Island, to the south of the estuary, to a straight line drawn in a south-westerly direction across Wareham Channel from the junction of a stream known as Wood Bar Looe with the channel. The Company also hold a grant of certain ponds on the foreshore opposite their packing house. The operations of the Company are said to consist in the main of laying down oysters in the Wareham Channel; chiefly East River, Caen Bay, and Solent oysters, but this Company during the last few years have failed to make any return to the Board of Trade.

The oyster ponds or pits already referred to are situated on the foreshore of Hamworthy, in a position which the accompanying large scale map indicates with sufficient accuracy. At the time of my visit,

the layings in the Wareham Channel were not in a productive state, and oysters imported from Brightlingsea and other places were being stored temporarily in these pits, for the purpose of being retailed to oyster merchants and others in the neighbouring towns. The pits in question are furnished with wooden sides and gravel bottoms, and are provided with sluices for emptying them when necessary; they are entirely covered at every high tide.

It will be seen by reference to the map that some 80 yards to the west of the Company's pits is the outfall of a drain coming from the Royal Naval Reserve practising shed. I was informed by the chief officer of the Coastguard that, on an average, there are about 30 men drilling at this shed. It is only fair, however, to state that drainage issues from the outlet in question only during such times as the men are at drill.

The Private Storage Pits of Poole.

These pits, four in number, are situated a short distance to the westward of the pits belonging to the Poole Oyster Company. They are held, like the latter, by virtue of a grant from the Board of Trade, and the lessee informed me at the time of my visit that he is taking steps to obtain a larger pit to the south of the pits referred to. The position of all these pits is diagrammatically represented on the map. The pits may be said to be used for the combined purposes of growing, fattening, and storage, the practice being to lay down immature oysters in the spring in readiness for the ensuing autumn.

From the map it will be seen that on the bank close by these pits are some houses which drain on to the foreshore, and at the time of my visit I counted six small outlets within a few yards of the pits. These drains receive, in some instances, the overflows from cesspools, and they cannot fail in their present relations to the pits to afford substantial risk of contamination to the contained oysters.

Into the waters of Quay Channel the liquid refuse of a large portion of the town of Poole discharges by numerous separate outfalls, while into Parkestone Bay, in the neighbourhood of Hospital Island, is also an outfall of the same description. Steps are now being taken by the Poole Corporation to divert the sewage of Poole and to carry it out to sea. This scheme, which is being vigorously pushed forward, should, when completed, have the effect of removing danger which now exists from this source. At Wareham, with a population of 2,000, at a distance of about six miles from the nearest oyster layings, there are, I am informed, overflows from a certain number of cesspools which find their way into the river.

The oyster pits in Poole Harbour must be regarded as amongst those which I found during the course of my inquiry to be exceptionally exposed to sewage pollution.

MAP TO SHOW POOLE OYSTER GROUNDS.

Map N° 17.



- Poole Oyster Company.
- Corporation Oyster Grounds.
- Non-appropriated Ground.
- Storage Pits of P.O.C.
- Private Storage Pits.

OLDOUT BL

MAP TO INDICATE RELATION OF OYSTER PITS AT HAMWORTHY, POOLE, TO DRAIN



ISLE OF WIGHT AND SOLENT OYSTER FISHERIES. (Map, No. 18.)

The Medina Oyster Fishery.

This river which rises at the foot of St. Catherine's Downs and empties itself into the Solent at Cowes, divides the Isle of Wight into two parts known as the East and West Medine. The river, from its source down to Newport, is of small dimensions, but at this point where it is joined by the Lukeley, a rivulet some three miles in length, it becomes a tidal stream which is navigable by vessels of small tonnage. At low tide there is at the upper part of the estuary, towards Newport, very little water, but lower down towards Cowes the river is navigable at all states of the tide. There are but few small rivulets entering the estuary between Newport and the sea, and indeed at no time does much upland water enter it; so that the displacement by this means of any sewage from the Medina into the Solent must be but a slow process.

The right of the oyster fishery in the Medina is leased at the present time by the Corporation of Newport to the Medina River Oyster Company. The existing lease gives power to the company to lay down and to fish for oysters from Newport Quay to the Floating Bridge at Cowes; but no oysters are, it is stated, now laid down within some two and half miles of Newport, *i.e.*, not landward of the "Folly" public house, the approximate position of which is indicated by the southern limit of the green coloration on the map. The company's operations consist chiefly in laying down in the Medina, French, Portuguese, and Solent oysters. In addition, the company has several oyster ponds on the shore of the river, a short distance above West Cowes. The ponds in question are at high tide level, and water is admitted into them by means of sluices. Oysters for market are dredged up from the river and deposited prior to sale in what is known as the "Ark," *i.e.*, a wooden house-boat possessing in part a false or moveable bottom, consisting of a cradle with perforated sides which allows the river water to pass freely over the oysters deposited therein. The cradle can be raised or lowered by means of a winch. This "Ark" is moored in the estuary near the ponds.

Coming now to the question of the sewage entering the Medina River. There are both at East and West Cowes numerous sewers discharging themselves at points indicated roughly by red crosses on the map. The main sewage outfalls both of East and West Cowes discharge, as a matter of fact, below the floating bridge; but the flowing tide cannot fail to carry the sewage from these and the other outlets above the ferry over the oyster layings. In addition to these sewers there are above the ferry a few closets belonging to works on the river side which discharge directly on to the foreshore. At the mouth of the several sewers, the position of which is indicated by buoys, the sewage may be seen rising up to the surface and discolouring the water for some distance around. There are, as will be seen, several sewers discharging into the Medina landward of Cowes ferry, and directly into that part hired by the company from the Corporation of Newport; and although it is stated no oysters are actually laid down in their immediate vicinity, dredging for oysters hereabouts certainly takes place, and I procured oysters from near these sewer outfalls on the occasion of my visit.

Newport, with a population at the last census of 10,216, discharges its crude sewage, directly into the river by several different outfalls all within a short distance of one another, the chief one being situated just seaward of the town quay. In connexion with the sewage of Newport, it may be remarked that during 1894 there occurred in Newport

an epidemic of enteric fever, no less than 436 cases being thus notified,* and that, according to Mr. Foster, the Medical Officer of Health for Newport, the excreta of all these patients must have passed either directly or indirectly into the Medina. Mr Foster advised the inhabitants of Newport not to eat oysters that were taken from the Medina during the outbreak.†

In addition to this, the sewage from the Newport workhouse, which building contains on an average some 290 persons, passes into a cesspool, the overflow from which finds its way into a ditch, and finally into the Medina estuary. The sewage as it emerges into the ditch exhibits much solid faeces, and paper, but most of this appears to become deposited before the Medina is reached.

The effluents from the convict prison and from the barracks at Parkhurst are combined, and after treatment with ferrozone and polarite pass into the Medina. There are, on an average, about 1,100 persons in the prison, and 700 soldiers in the barracks. We therefore have at varying points above and below the Medina layings:—

1. Part of the sewage of West Cowes (total pop. 7,690).
2. The sewage of East Cowes (pop. 2,872).
3. The sewage of Newport (pop. 10,216).
4. Overflow from workhouse cesspool (pop. 290).
5. Effluent from prison and barracks (pop. 1,800).

Having regard to all the above facts, it must be conceded that the River Medina in its present condition is an estuary in which to fatten oysters for market ought not to be contemplated.

In my inspection of the Medina, as also in that of other places in the Isle of Wight, I received much valuable assistance from Dr. Groves, Medical Officer of Health to the Rural Sanitary District of the island.

The Oyster Layings in Newtown Estuary.

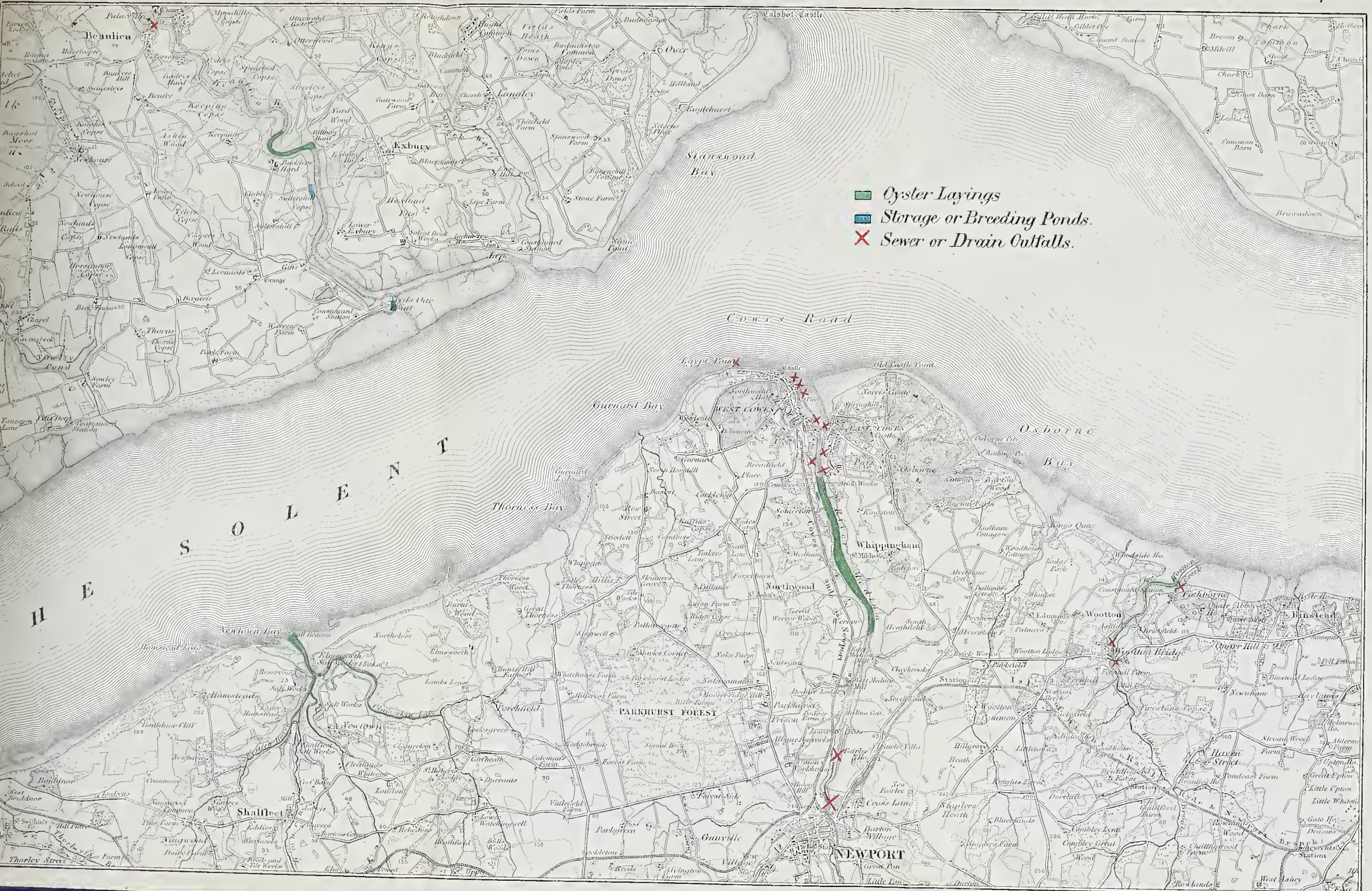
This estuary comprises a series of creeks, into which fall a number of small streams serving for the natural drainage of a considerable area of the north-west of the Isle of Wight. The chief of these creeks are, taking them from west to east, Western Haven, Shalfleet Creek, Newtown Creek, and Clamerkin Lake.

The Newtown estuary has served as an oyster fishery for many years, and it was formerly held in conjunction with the Medina river by the Isle of Wight Oyster Company. Numerous attempts have been made here, and much money has been expended, in the promotion of artificial oyster culture after the French methods, and the ponds in which these attempts were made are still in existence. Although there are, I am informed, some oysters in this estuary that have developed from native spat deposited there, the chief operations at Newtown at the present time consist in relaying oysters and brood dredged up elsewhere. The brood and immature oysters are purchased for the most part from the Solent fishermen, who temporarily store their catch in Wootton Creek, Hamble River, or other convenient localities, until sufficient quantity has been collected. It is then brought to a floating store at West Cowes, which is also used for marketable oysters, where it is kept pending its removal to the Newtown layings. It may be here remarked

* "Dr. Theodore Thomson's Report to the Local Government Board on an Epidemic of Enteric Fever in the Borough of Newport (Isle of Wight) and in certain parts of the adjoining Isle of Wight Rural District."

† Since this report was written sewage works have been constructed at Newport for the chemical treatment of the sewage and the discharge of the effluent only into the Medina.

MAP TO SHOW POSITION OF OYSTER LAYINGS AND PONDS IN THE ISLE OF WIGHT AND THE BEAULIEU RIVER. Map No 18.



that the floating store referred to is moored close by one of the West Cowes sewage outfalls, at the entrance of the river, and that the store should not therefore, in its present position, be used for marketable oysters. The brood and immature oysters are taken to Newtown by boat, and laid down in certain selected localities situated in Clamerkin Creek and Western Haven, while near the mouth of the estuary are certain other layings for oysters requiring deeper water. In Shalfleet Creek no oysters are laid, but in a small "Gut" leading out of this creek is a floating storage tank wherein oysters are at times collected prior to their despatch to market.

There appears to be little, if any, sewage entering the waters of the Newtown estuary; and although there are small villages near each of the streams entering the several arms of the estuary, all the drains of these villages have been, as far as I was able to gather, diverted from the streams in question. The inhabitants of Shalfleet drink the waters of the Caulbourne, as the stream passes through the village.

Oyster Layings in Wootton Creek.

This is a tidal creek situated on the north of the Isle of Wight, near Fishbourne, a village about midway between Cowes and Ryde. The creek extends about two miles inland, to a point where a small brook, known as Blackbridge Brook, falls into it. At high tide there is a considerable expanse of water in this creek, but at low water the waterway is of but small dimensions. Oysters and brood are, I am informed, laid down, for fattening and growing purposes, over so much of the creek as extends from the village of Wootton to its mouth, a distance of about one mile.

There are also situated on the foreshore, just seaward of Wootton Mill, some half a dozen small oyster pits belonging to local fishermen. In these ponds are deposited brood and oysters dredged up in the Solent; the oysters being apparently sold in the best market, while the brood is for the most part, disposed of to oyster merchants for laying down purposes. The position of these ponds is an altogether improper one. On either side of them and distant only about 80 yards away in each instance is a sewer outfall from the village of Wootton, while rather nearer, is a closet used by sailors frequenting the quay, which discharges immediately on to the foreshore. Just alongside the ponds is a channel conveying what appears to be the overflow from a duck pond hard by. There is also much domestic refuse on the foreshore hereabouts. On the opposite side of the channel just landward of Wootton Bridge, are the outlets of two small drains serving houses on the east side of the river.

At Fishbourne there are other oyster pits excavated on the foreshore on the western side of the channel almost immediately opposite the coast-guard station. These pits were constructed and are used by fishermen, who dredge up brood and oysters from the Solent, and deposit them either in the bed of the creek or in these pits. These oysters are sold in the Island and oyster merchants purchase the brood. A few small drains discharge on to the foreshore at Fishbourne, but on the opposite side of the creek to that on which these pits are situated.

SOUTHAMPTON WATER FISHERIES.

Hamble Oyster Ponds. (Map, No. 19.)

Attempts at the breeding and fattening of oysters were made in former years in the River Hamble, which flows into Southampton Water on its eastern side. At the present time, however, there are here none but what may be called storage and fattening ponds. Some of these are situated

near the village of Hamble on the northern side of the river, the others near Warsash on the southern side.

The position of the ponds at Hamble is represented on the annexed map, the larger of the two ponds being used as a backwater for flushing the lower and smaller pond when necessary. The oysters stored here are mainly French. As regards pollution of the river hereabouts, it will be seen that the main drain of the village of Hamble discharges near the quay, which is within about 140 yards of the ponds; there are also other small drains hereabouts. Locally, it is considered that polluting matters from Hamble drains would have considerable difficulty in reaching the storage pits, owing to the fact that the pits are raised above the level of the surrounding foreshore by means of a gravel hard, which is only covered when the tide is well up. This would, to say the least, ensure very great dilution of any sewage which might be contained in the water.

Warsash Storage Pits. (Map, No. 19.)

These pits are but a short distance below Hamble village, but on the opposite side of the river. There is here a lobster pond in the position shown on the map, into which oysters and oyster brood are also placed for fattening or growth. Near to the intakes—two in number—of this lobster pond is the outlet of a small sewer from some dozen houses, which, at the time of my visit was discharging black filth within about 12 yards of the intakes. The pollution by sewage of the water entering this pond is practically ensured.

On the foreshore just beyond this, and opposite the "Rising Sun" public house, are some small storage ponds belonging to local fishermen who dredge up oysters in the Solent. The sewer outlet to which reference has just been made, was, at the time of my visit, found to be within some 25 yards of the pond nearest to it, and complaints were made to me that it had not been lengthened so as to take the sewage further away. Lengthening would, of course, have the effect of diminishing the obvious danger which at present threatens both the lobster pond and oyster pits, though such a proceeding would not altogether remove it.

THE OYSTER PONDS AND BEDS OF THE BEAULIEU RIVER. (Map, No. 18.)

I was informed by the manager of this oyster fishery that native oysters are found all along the river, and that just above and below what is known as Buckler's Hard, oysters—foreign and native—are laid down.

On the western bank of the river, about a mile seaward of Buckler's Hard are two large breeding ponds, in which attempts have from time to time been made to breed oysters after the French method.* There are also other ponds near the mouth of the Beaulieu River in which young oysters taken from the Solent are placed prior to being laid down.

Two small drains from houses at Buckler's Hard discharge into that portion of the river used for layings, and some four miles landward, the

* Experiments have been conducted in these ponds since the year 1878, and an interesting account of the methods adopted will be found in the Journal of the Marine Biological Association, Vol. I., New Series (No. 3). The account is from the pen of Lord Montague of Beaulieu, the owner of the ponds, who has taken much interest in the subject of oyster culture.

MAP TO SHOW RELATIONS OF HAMBLE AND
VARSASH OYSTER PONDS TO SEWER OUTFALLS.



river receives drainage from the few houses at Beaulieu; the amount is, however, so very small that it can hardly affect the breeding and storage ponds.

THE EMSWORTH OYSTER FISHERIES. (Maps, No. 20A and 20.)

The Emsworth Channel is mainly vested in the present representatives of two oyster Companies; the Oyster Merchants Company, and the Emsworth Dredgermen's Co-operative Society.

The grounds belonging to the former Company not now in use, are by way of being administered by the Poole Oyster Fishery Company. The Dredgermen's Company unfortunately, is also not in a very flourishing condition, although at the time of my visit a quantity of brood had been a year or two on the grounds. This Company has, besides its layings in the channel, a few storage pits on the foreshore off Emsworth, but it does not seem that the pits in question are much used. In 1894-5, 400 oysters, worth 1*l.* 4*s.* 0*d.*, were the total produce of the Emsworth Channel Fishery.

In addition to the above Companies, there are two private oyster merchants at Emsworth. One of these merchants has oyster layings at South Hayling, Gutner's Creek, and Emsworth, and at the latter place he has also numerous storage pits. The other merchant has storage pits only, and these are in proximity to those just referred to. In these pits which are situated on the foreshore immediately opposite to the town of Emsworth, are deposited numerous foreign oysters both for storage and fattening, and from thence the oysters are despatched direct to market.

It will be necessary now to make detailed reference to the several outfalls of the Emsworth sewage, and to indicate, by means of the map appended, their relations to the storage pits. In this connexion I am much indebted to Dr. Lockhart Stephens, the Medical Officer of Health to the Warblington Urban Sanitary District, who was good enough to show me all the outfalls in question and to give me much information in regard to them.

The sewage of Emsworth, with a population of 1,550, consists of slop and storm water, together with the overflows of numerous cesspools. It is collected for the most part by means of one main sewer which takes the drainage from some 300 houses, and discharges within a few yards to the south-east of the oyster grounds, near the point A on the accompanying map. In addition to this main sewer there are other and subsidiary sewers discharging as follows:—At the point marked B, in the very midst of the ponds, a sewer which takes the drainage from some 12 houses in Tower Street; at C, another, similarly situated, which takes the drainage from four or five houses on the Trentham Hall estate; and at D, a third, close by, which drains a single house only. Eastward of these outlets are other and smaller ones, discharging into the foreshore at points marked with red crosses on the map. Near to the "Dolphin Inn," *i.e.*, quarter of a mile north of Hendy's Quay, which place will be seen on the map, there discharges a large sewer.

It would hardly seem necessary, in view of the relations between the sewer outlets and the storage pits depicted on the accompanying map, to dwell upon the gross contaminations to which the oysters here stored must be liable.

In no single instance is Emsworth sewage discharged into tidal waters in other than a crude condition.

The danger to which the few oysters now laid down in Emsworth Channel are subjected from this Emsworth sewage is trifling in comparison with that to which the oysters in the storage ponds are exposed under the conditions I have set forth above.

THE OYSTER PONDS AND LAYINGS ON HAYLING ISLAND, AND IN
LANGSTON HARBOUR. (Map, No. 20).

On the littoral of Hayling Island are some of the best constructed oyster ponds that I have seen. For the most part, these ponds were built at a very considerable outlay by the old South of England Oyster Company. They are now in other hands. One set of them is the property of the National Oyster and Lobster Culture Company, Limited; the other, that of the Ham and Seasalter Oyster Company, whose headquarters are at Whitstable. In addition to these ponds there are certain layings in the creeks situated on the west of the island.

The ponds belonging to the National Oyster and Lobster Culture Company (Limited), are situated near the north-west corner of Hayling Island. They are extremely well constructed, and consist of numerous basins of various sizes into which water can be admitted at will during high tide by means of sluices communicating with Langston Harbour. The ponds themselves are also in connexion, either directly or indirectly with one another, through the agency of sluices. In addition, a large backwater can be used for feeding the ponds during periods of storm, or for the purpose of flushing them. In connexion with some of the sluices are arrangements for the spraying and aëration of the water.

The Company which has acquired these ponds, proposes to work them in conjunction with fattening beds situated in the East Swale, Kent, the Hayling ponds being used in the main for breeding and wintering purposes.

I was informed by Mr. Collins, the secretary to the Company, who was good enough to show me over the ponds, and afford me information in regard to them, that there had been during 1893 and 1894 a heavy fall of spat there, the spat having been collected either on cemented tiles after the French method, or upon fascines according to the Italian method.

In Langston Harbour, to the west of Baker's Island, as shown on the map, are the winter layings of the Whitstable Oyster Company. These layings are used for the storage of foreign oysters during the winter months, but no oysters are, I am informed, ever sent to market from here.

A reference to the map will convey some idea of the vast body of water accumulated in Langston Harbour at high tide, at which time any water required for feeding the ponds is taken in. The slop water of Havant, which enters the mill stream in that town, finds its way, after undergoing some degree of subsidence in the mill ponds, into the waters of Langston Harbour, a short distance to the west of the railway bridge. As to the sewage of Portsmouth; this is stored during the flowing tide in large storage tanks, situated near the outfall into the sea just westward of the mouth of Langston Harbour. It is let out on the ebbing tide. Before fixing upon this point of discharge for the Portsmouth sewer a series of experiments were made, which demonstrated that floats placed in the tideway soon after high water, were carried out many miles to sea, and arrangements were, therefore, made to take advantage of this circumstance. The Corporation of Portsmouth are under the obligation to the War Department to dispose of their sewage in such a manner as not to foul the foreshore; but it appears that it has been necessary to construct separate surface water sewers in order to enable all the sewage to be liberated on the ebb tide. Obviously if the sewage were allowed to be discharged on the flowing tide there would be danger of its being carried into Langston Harbour.



The South Hayling Oyster Ponds and Layings. (Map, No. 20.)

These ponds, which are situated near the south-eastern corner of Hayling Island, not far from the mouth of Chichester Channel, were constructed partly by the Ham and Seasalter Oyster Company and partly by the South of England Oyster Company. There are really two separate sets, the general arrangements of the ponds in both sets being very similar to those belonging to the National Oyster and Lobster Culture Company, to which reference has already been made.

These ponds are used mainly for wintering oysters brought from the beds of the Ham and Seasalter Company, at Whitstable; but attempts are also made in some of the ponds to obtain spat from oysters and to rear the progeny. At the time of my visit in the spring of 1895, the oysters which had been laid down during the winter were being culled over in the ponds; for owing to the exceptional severity of the season a very heavy mortality had been experienced, and this in spite of the vigorous efforts which had been made by artificial means to keep up the temperature of the pond water. I was informed by Mr. Gann, manager of the beds, to whom I am indebted for many interesting points concerning oyster culture in this country, that the loss had been not far short of 50 per cent. upon the whole stock wintered. In addition to the ponds referred to, there are oyster layings in the creeks hereabouts, both to the north and south of the breeding ponds.

Although these ponds are used in the main for breeding and wintering purposes, Mr. Gann informed me that on occasions when the marketable stock at Whitstable is by any chance exhausted, oysters may be sent to market direct from the South Hayling ponds. As regards the ponds, I see no reason to regard the oysters in them as liable to contamination, and the same remark applies to the layings in the creek south of the ponds.

There are, however, some layings, for the most part private ones, situated to the north of the ponds, near My Lord's Pool, which can hardly be regarded as really free from pollution, inasmuch as the drainage from about 24 houses finds its way into the creek in which the layings are situated, and at a point not more than one third of a mile above them.*

The only other layings in the neighbourhood of Hayling Island are those situated in Gutner Creek, to the west of Emsworth channel, between Gutner Common and Vernon Common. There are several layings here in the bed of the creek, all of which belong to private oyster merchants. One of these merchants has storage ponds at Emsworth, in which oysters from these Gutner layings are placed prior to sale. The other merchants send away their oysters direct from the layings to market. In this creek all the layings appear to be practically free from risk of contamination.

* In connexion with certain layings in this same creek, it may be recorded that a short time ago several cases of gastritis occurred amongst persons who had consumed oysters taken directly therefrom. There is near this creek a holiday settlement, where for a short time during the summer months a number of boys camp out. The excrement from this camp is thought to have found its way down to the oyster layings, and with a result as above related. Steps were immediately taken to rectify this matter, and the excrement from the camp is now, I am informed by the sanitary inspector of the district, otherwise disposed of. Dr. May, of South Hayling, was good enough to furnish me with particulars in reference to these cases of gastritis.

BOSHAM OYSTER FISHERY (Maps, No. 20 and 21.)

By the Oyster and Mussel Fisheries Order Confirmation Act, 1873, the right of a "Several" oyster and mussel fishery was conferred upon the Bosham Dredgemen's Co-operative Society, Limited. The limits of the fishery would appear to embrace Bosham and Chichester Channels below low-water mark at ordinary neap tides, but the actual operations of the Company do not extend further towards Chichester than the junction of Bosham Channel with Chichester Channel. In addition to the area thus indicated, the Company possess three storage ponds opposite the village of Bosham, in the position coloured green on the map.

Part of the channel contained within the jurisdiction of the Company is, as a general rule, utilised for rearing indigenous oysters; part for laying down foreign oysters. Oysters, of whichever sort, dredged up for purpose of consumption are deposited for a short time—probably over one night—in the storage ponds opposite Bosham village. In the severe winter of 1894-5, this Company lost a very large number of French oysters as well as some "natives" from the effects of the frost.

About four miles above the highest oyster layings in Chichester Channel, there is discharged at the beginning of ebb-tide the effluent from the Chichester Sewage Works. These works have been but recently completed, and at the time of my last visit to the district I was informed that but few houses had been yet connected with the public sewer. The method of treatment of the sewage is with chemical precipitation, and subsidence in settling tanks. The supernatant fluid is disposed of by downward intermittent filtration through land, the effluent from which is collected in a storage tank and let out only during the first three hours of the ebbing tide.

As regards the Bosham Channel, the condition of the foreshore near to the oyster ponds is far from satisfactory. At points marked by red crosses on the large-scale map (No. 21.) are outlets from slop drains or waterclosets, while the foreshore, in front of the houses and in the vicinity of the oyster ponds, is littered with much heterogeneous débris. Efforts have been made by Captain Jarrad, R.N., the managing director of the oyster Company, to whom I am indebted for much information, to bring about a better state of the foreshore; but hitherto his attempts have not been successful.

Certainly the condition of the foreshore, on the occasions on which I have visited Bosham, constituted a serious menace to the cleanliness of any oysters deposited in these ponds. It should not be a difficult matter to obtain storage ponds near to Bosham which would be free from such obvious risks.

SHOREHAM HARBOUR. (Map, No. 22.)

Shoreham Storage Pond.

At one time Shoreham was a very large centre for the despatch of deep-sea oysters to Billingsgate, and some idea of the business formerly done here may be gathered from the enormous number of disused oyster ponds still in existence, and represented on the accompanying map in the locality of the New Shoreham Bridges. At the present time, however, there is no trade of any magnitude done in oysters at Shoreham, and beyond one small pond located in the position coloured green on the map, in which a local oyster merchant temporarily stores his oysters, all the ponds are, I am informed, disused. The New Shoreham sewage, after filtration through coke, is discharged into the river in the position

MAP TO SHOW OYSTER GROUNDS, PONDS ETC ON AND AROUND HAYLING ISLAND.

Map No 20.



(For Emsworth and Bosham Storage Ponds see other maps.)

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MAP TO SHOW RELATIONS OF BOSHAM STORAGE PITS TO DRAIN OUTFALL



indicated by the most western red cross in the map. The oyster storage pond to which reference has been made is separated from this outfall by the width of the river; but it is clear that the pond is in an undesirable position. There are also some small sewer or drain outlets along the eastern arm of Shoreham Harbour, one of which discharges the drainage from Kingston Terrace.

The Southwick Oyster Layings and Storage Ponds.

There are, at Southwick, certain oyster layings situated in what is known as the South Channel in the position coloured green, in Shoreham Harbour, on the annexed map. Oysters from these layings are stored for purposes of convenience and accessibility in artificially constructed ponds, situated on the foreshore, to the westward of the wharves. These are also shown on the map.* When required for market the oysters are lifted from the ponds by means of a fork, rinsed in the pond water, and despatched forthwith to market.

These oyster ponds are almost immediately flanked on both sides by sewers discharging into the River Adur some feet above low-water mark, in positions indicated with sufficient accuracy by red crosses on the map. I was informed by Mr. Gates, the sanitary inspector to the Steyning Rural Sanitary District, that the sewer to the westward of the oyster pits conveys the drainage from some 25 houses, while that to the eastward receives the overflow from a cesspool which collects the drainage from eight houses or thereabouts. The outlet of the sewer, in each case, is only a few yards distant from the nearest oyster pond, but is at a lower level of the foreshore. Originally these two sewers discharged on to the foreshore at a considerably higher level, but owing to certain representations made to the owners of the oyster ponds, the outlets were carried down to their present positions below the ponds in question. In addition to these two sewers there are in the docks to the eastward of the ponds as represented on the map, three other sewer outfalls. One of these, that furthest to the east, is the main Southwick outfall, which is distant about 250 yards from the nearest oyster pond. The condition of these docks is highly offensive. Having regard to the relation of the several outlets in question to the oyster ponds, oysters stored here must be liable in a high degree to danger of sewage pollution. The ponds are covered by water at high tide, so that contaminated water from the sewers near at hand can, twice in 24 hours, find its way into the ponds.

The oyster layings in South Channel are no doubt less exposed to danger of contamination than those in the ponds; but bearing in mind the circumstance that at absolute low water sewage from the Southwick outfalls tends to collect in the channel below the oyster ponds, it is obvious that sewage matter can hardly fail, on the flood tide, to be swept with the incoming tide up South Channel over the oyster layings that are in question, more especially since the lock gates preclude the passage of water into the eastern arm of New Shoreham Harbour (see map). I was not able to ascertain on the occasion of my visits to Southwick all the pollutions that find their way into this eastern arm of Shoreham Harbour, but I was informed at my last visit that a survey of this part was about to be made. Sufficient has, however, come to light for the purpose of demonstrating that the Southwick oyster ponds are in a most improper and unsafe position. This fact has been brought to the notice of the oyster merchant owning the ponds on several

* The pits are rather more numerous than shown.

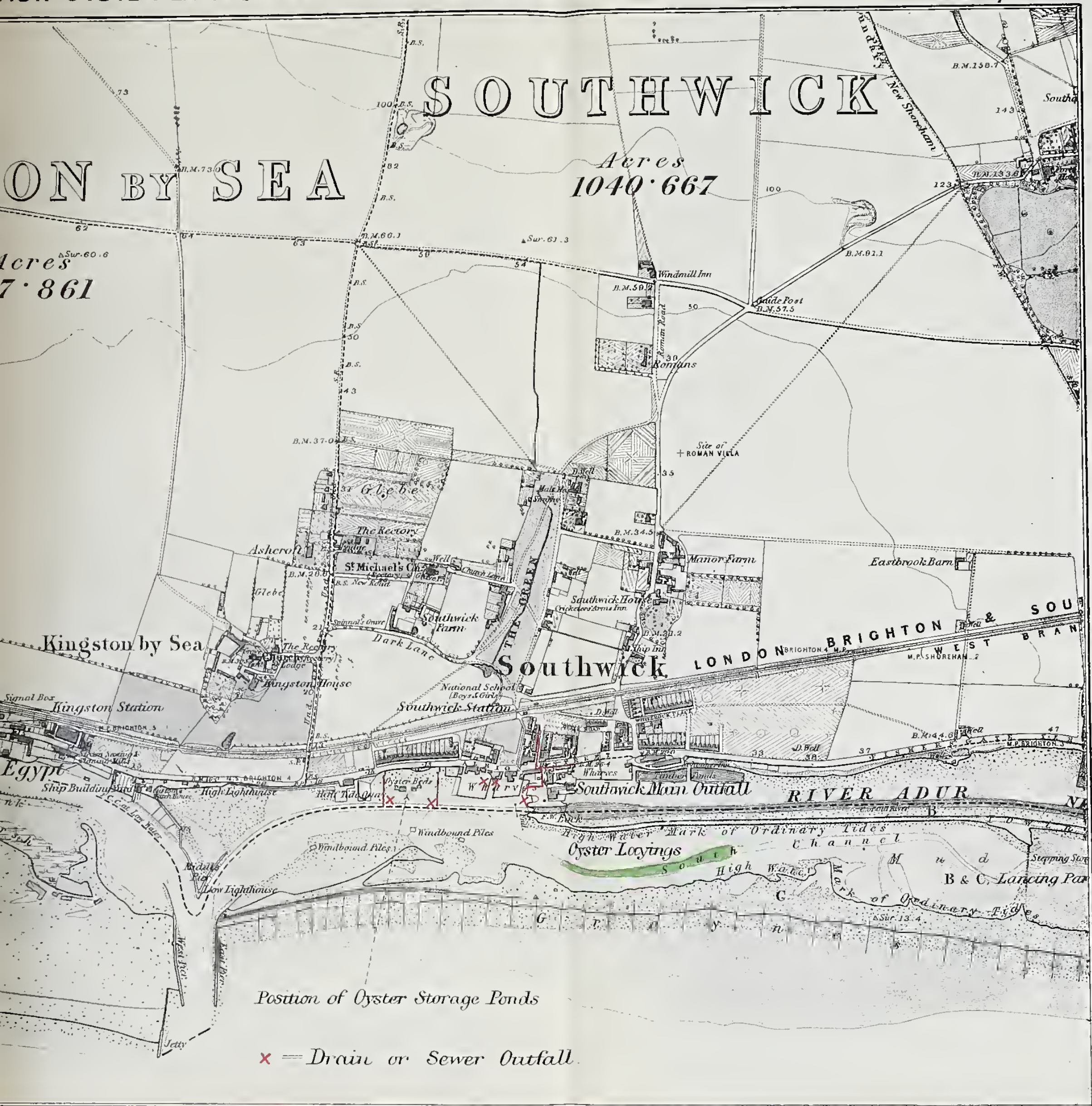
occasions by Dr. Newsholme, the Medical Officer of Health of Brighton ; but thus far without result.

It must also be added that Dr. Newsholme has, in his official capacity, reported that cases of enteric fever in Brighton have, in his opinion, on more than one occasion, been due to the consumption of oysters from these ponds.* I endeavoured to procure some of these oysters for the purpose of bacteriological examination, but the proprietors refused to sell me any oysters for this purpose.

* Reverting to this subject in his recent report on the health of Brighton during the year 1895, Dr. Newsholme writes as follows :—

“During 1895, 87 cases were notified to me as typhoid fever. Of these, 12 were subsequently ascertained not to be typhoid fever, and in 19 other cases it was discovered that the disease had been acquired before the patient arrived in Brighton. This leaves 56 cases to be accounted for, which apparently originated at Brighton. In my last annual report, I made the statement that ‘at least 40 per cent. of the cases of enteric fever originating in Brighton during 1894 were ascribable to sewage-contaminated shell-fish.’ The cases of typhoid fever occurring in 1895 were similarly investigated, with the result that in 35 cases it appeared that no shell-fish had been taken prior to the attack of fever, in 2 there was doubt on this point, in 7 the attack was directly ascribable to oysters, and in 12 to other shell-fish eaten raw. Thus during 1895, 30·4 per cent. of the total cases originating in Brighton were attributable to shell-fish.

“The evidence connecting these 19 cases with the consumption of raw sewage-contaminated shell-fish did not consist simply in the fact that shell-fish had been consumed within three weeks before the date of onset of the disease. Such an order of events, occurring in a rapid succession of cases, would have served to justify a serious suspicion that the shell-fish were connected with the typhoid fever in the relationship of cause and effect rather than accidentally. The facts when investigated in detail were much more conclusive, comprising as they did the significant circumstances that in the majority of cases, either (a) the one person taking the shell-fish was the one person acquiring typhoid fever, or (b) when other persons in the same house had eaten shell-fish they had diarrhœa or other evidence of illness, although this did not develop into actual typhoid fever. When we add to this, that sewage-derived organisms were found in the interior of oysters derived from the same beds or ponds, the evidence becomes as strong as it can in the nature of things be in a medical inquiry concerned with circumstances of life necessarily complex in character.”



OYSTER FISHERIES AT THE MOUTH OF THE SWALE.

The Ham and Seasalter Company. (Maps, Nos. 23 and 24.)

This Company possesses as an oyster fishery, or fisheries, two pieces of water situated near the mouth of the East Swale, nearly opposite Whitstable; the one known as the Pollard, which lies immediately to the westward of the Whitstable Oyster Company's ground; the other, known as the Ham ground, a roughly triangular area situated immediately to the north-east of the Faversham Oyster Company's grounds. Only a portion of each of these grounds is at the present time used for oyster layings, and the areas thus utilised are roughly indicated in yellow on the accompanying map. Furthermore, it should be pointed out that only certain portions of even the areas in question are utilised for laying down what may be termed marketable oysters. Some idea of the operations of this Company may be gathered from the table inserted below, which was furnished by Captain Austin, the chairman of the Company.*

Oysters required for market are dredged up from the layings, taken to a sorting-house on shore, and culled over. Those for the London market are, I am informed, packed up in tubs, boxes, or bags, and despatched at once; those for the more local markets, if not sent off at once, are deposited in storage pits until required. The storage pits, two in number, are excavations below the floor level of the sorting-house.

The sorting-house here referred to is situated just to the east of Whitstable Harbour, and the water intake to the storage pits consists of a closed culvert, the seaward end of which is but a few yards to the east of Whitstable Harbour Pier (see Map 24). This end is furnished with a flap, and the sides of the culvert for some distance up are perforated.

I am informed that the water in the pits is changed daily, the stale water being let out just before the ascending tide reaches the mouth of the intake, and fresh water being taken in when the intake is well covered by the flood. The pits are constructed of concrete lined with cement, the oysters being suspended in the water by means of nets which are hung from beams passed across the tops of the pits.

* TABLE showing the NUMBER of OYSTERS LAID DOWN and the NUMBER SOLD during the Years 1879-92 by the HAM AND SEASALTER COMPANY.

Year.	Oysters Laid.	Year.	Oysters Sold.
1879-80	4,750,000	1880-81	4,993,000
1880-81	11,335,000	1881-82	6,812,000
1881-82	14,352,000	1882-83	3,609,000
1882-83	8,009,000	1883-84	7,603,000
1883-84	16,124,000	1884-85	6,068,000
1884-85	14,222,000	1885-86	6,946,000
1885-86	18,947,000	1886-87	7,163,000
1886-87	22,765,000	1887-88	11,713,000
1887-88	27,669,000	1888-89	8,427,000
1888-89	22,303,000	1889-90	10,585,000
1889-90	20,263,000	1890-91	9,211,000
1890-91	28,943,000	1891-92	9,336,000
1891-92	23,659,000	1892-93	6,412,000
1892-93	7,452,000	1893-94	5,848,000
Total	240,793,000	Total	104,726,000

On the occasions of my visits these pits presented a very cleanly aspect, as indeed, did the whole building and all it contained. Between 1858 and 1888, when the present pits were constructed, the operations were carried on without the aid of pits. It was considered, however, that the possession of storage provision of this sort would tend to facilitate the transactions, as appears to have proved the case. It is well to bear in mind, however, that these storage pits are by no means essential to the business operations of the Company.

In reference to the sewer outfalls of Whitstable, which town has an estimated population of some 5,600, I interviewed the representative of the Commissioners of Sewers, who lives at Canterbury. He informed me that altogether there are three outlets: one, the main outfall, situated at the mouth of the harbour in the position indicated approximately by the central of the three red crosses on Map No. 24; another, a small one, which drains some 16 houses at Lower Island, situated just beyond the western extremity of the town; and a third—really outside the Whitstable district—which takes the drainage from the Tankerton Estate, and discharges just to the east of what is known as “Whitstable Street,” a shingle bank which dries before low water. The two last-mentioned outfalls are very small as compared with the Whitstable main outfall.

The Whitstable main sewer is provided with a tidal flap and a penstock, the former being apparently a substitute for the latter. I visited this outfall some two hours after high water and found the sewage issuing from the outlet in considerable volume, a similar condition of affairs obtaining at two hours before high water. The sewage tends on the ebb tide to pass directly out to sea, but at an early stage of the ebb there is a current setting directly round the pier head (see Map No. 24). and passing the intake of the storage pits, to which reference has been made. As the tide ebbs further the intake is, however, left high and dry, and is cut off from the harbour by a sandbank known as the Paddock. During this time the sewage from Whitstable will have a tendency to pass directly out to sea, being prevented from drifting to the eastward by the sandbank referred to. The distance of the intake of the Ham and Seasalter storage pits from the Whitstable outfall, as measured by a rotameter on the 25-inch Ordnance map, is about 210 yards.

In judging of the risk of sewage pollution to which the water admitted at the intake in question may have been liable, it is necessary to bear in mind that water is not admitted on the ebb tide, but only on the flood tide, at which time no sewage from the harbour passes the intake; and having regard to this fact, it is probable that the risk of sewage contamination to the water entering the pit must be but slight. Still, when the proximity of the Whitstable outfall to the intake is held in view, and the drift of the harbour water at certain states of the ebb is remembered, it must be admitted that there is risk of the deposition of sewage on the foreshore near to the intake, which might possibly be washed into the pipe on the flood tide. Fortunately, as has been observed, the pits are not necessary for the operation of the Company.

As regards the layings themselves, they lie out at sea; the Pollard layings are from over 1 mile to about 2 miles from the sewer outfalls, and the Ham layings are about $3\frac{1}{2}$ miles away; and they must, it seems to me, be regarded as practically free from liability to contamination with Whitstable sewage. The sludge from the London sewage works is deposited in Barrow Deep, distant some 9 or 10 miles from these layings.

The Whitstable Oyster Company. (Maps, Nos. 23 and 24.)

The Whitstable Free Dredgermen's Oyster Company, is, probably, the best known of all the oyster companies in Great Britain, and the town of Whitstable has been perhaps more closely associated in name with the oyster industry than any other. From almost time immemorial Whitstable has been noted for the quality of its oysters, and as far back as 1793 this Company procured by Royal Charter the right of an oyster fishery over a portion of the Kentish Flats opposite Whitstable, measuring some $1\frac{1}{2}$ miles square. The Company is a co-operative society comprising some 400 members, all of whom have obtained entry as matter of hereditary privilege. In former years, membership was granted to all sons of freemen, but as this tended to too great a division of profits, it was determined to limit the hereditary privilege to the eldest sons of freemen alone. Each member of the Company has an interest in the profits, and is entitled to be employed by turn in the performance of the work connected with the oyster industry. The grounds of the Company are situated opposite Whitstable, which town occupies, approximately speaking, a position midway between the eastern and western limits of the fishery. These limits tend to diverge as they pass out to sea, so that at a distance from the shore the east and west boundaries are rather more remote from one another than they are on the foreshore. Although, as has been stated, the area over which the Company has jurisdiction measures some $1\frac{1}{2}$ miles square, the actual operations of the Company are confined to a much narrower space than this, viz., to an area coloured red on the map, which, according to my information, may be regarded as the seaward portion of the grounds, the shoreward portion being used in the main for anchorage. The seaward portion may be again divided into what may be called the "preparatory," and the "marketable" grounds; the western portion of the smaller area being used for marketable stock, whether English or foreign, the eastward portion for immature oysters. It will thus be seen that the marketable beds are confined to the north-western portion of the whole area. On the eastern side of the Company's grounds brood developed from spat deposited here in the course of nature is—in favourable years—dredged up, but no marketable oysters are, I am told, taken hereabouts.

The business done by the Whitstable Oyster Company in what are known as "Whitstable natives" is so large that the natural yield, so to speak, of the Company's ground affords but a small portion of the supply required. This yield, therefore, is supplemented by brood of "native" oysters brought from the common grounds of the Kentish and Essex Flats near by. From the flats in question such brood is dredged up by dredgermen generally, and is purchased by the Company, while much is also procured at times from oyster merchants in Essex. The Whitstable grounds, though at times yielding much "native" spat, are in the main remarkable for their fattening properties, and the fattening of oysters procured from other sources, whether English or foreign, must be regarded as the principal feature of the Company's operations.

Oysters when required for market are dredged up from the "marketable" ground and brought to the sorting-house of the Company situated on the foreshore at Whitstable. They are here culled over, and despatched in boxes or bags to their destination. Such oysters as are not required for immediate despatch are kept in the storage pits, situated below the sorting-house, where they are suspended in water taken in fresh daily from the sea (see Map No. 24). I have visited these pits on several occasions, and they have always presented a very cleanly appearance; the intake to them is situated on the foreshore, just outside the sorting-house, its inlet being at ground level.

As to the layings themselves, it is difficult, having regard to all the considerations, to think of them as exposed to risk from the Whitstable sewage. It has to be remembered that on the first of the ebb, the water from Whitstable Harbour, which carries with it the Whitstable sewage, runs strongly round the Whitstable Pier and passes to the eastward. At this time, therefore, the sewage does not approach within two miles of the marketable layings. At later ebb the harbour water, or so much of it as is left at this stage, is prevented from running to the eastward immediately after passing the pier, by the presence of a sandbank which dries at late ebb; it therefore passes out to sea until the end of 'the "Street Stones,"' when it turns to the eastward at a distance of nearly a mile from the market layings. At and near low water but little if any sewage can obtain exit from the harbour, and consequently there is little or nothing passing the end of the Stones to be met by the incoming tide. On looking, however, at the condition of sewage disposal at Whitstable and to the offensive condition of the harbour itself at low tides, one could not fail to be impressed by the facilities which appear to be afforded of intercepting the sewage and carrying it to the eastward beyond the Street Stones, where presumably it might be liberated on the ebb tide.

As the result of my inquiries and observations I was unable to trace any visible sewage pollution as far out to sea as the existing layings; this result is probably due to the vast body of water here in question. The distance between the layings and the sewer outfalls is some 2 miles.

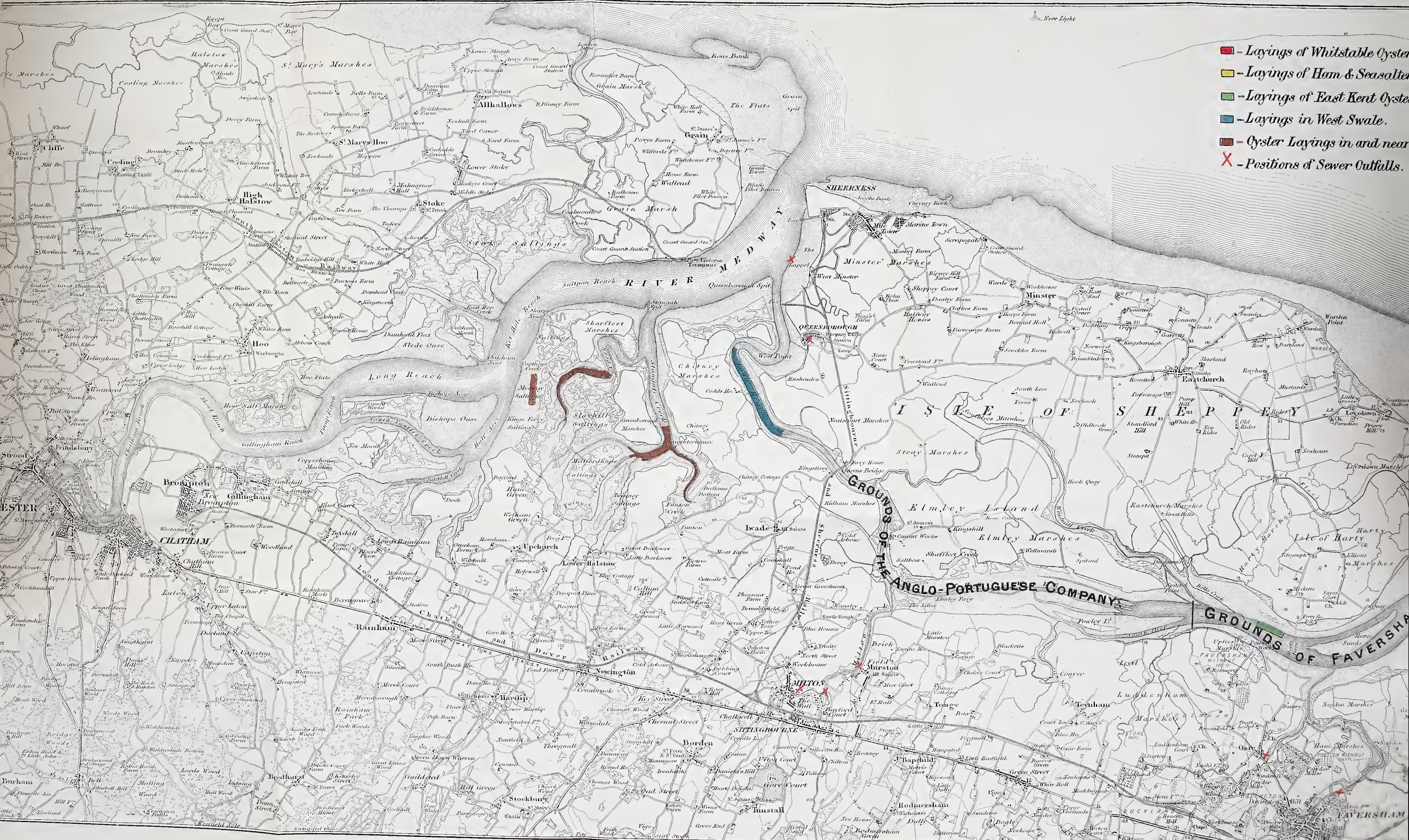
The sorting-house of the Company is distant just under a quarter of a mile to the westward of the Whitstable main outfall. Any risk of pollution from this source to oysters stored in the storage pits and the sorting-house would have to take place at the flood tide, and this does not seem to be great having regard to the cleanly nature of the beach in the neighbourhood of the intake. In reference, however, to this intake, the opening of which is at the level of the foreshore, it appeared to me that if it was lengthened and the end bent up in such fashion as to allow of water entering late on in the flood only, such risks as there may at times possibly be, would be obviated.

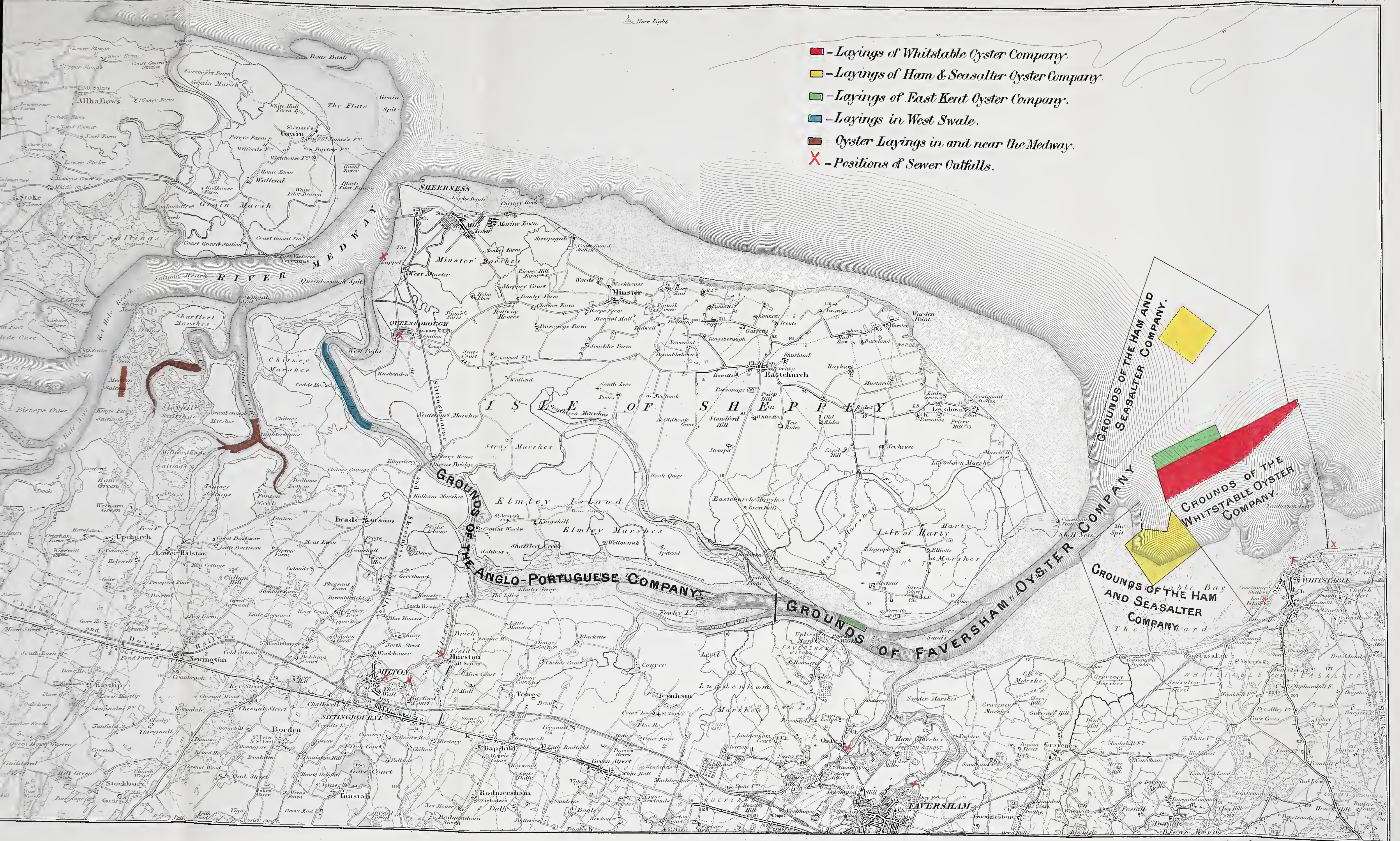
THE OYSTER LAYINGS IN THE SWALE. (Map, No. 23.)

The fishery rights in the West Swale from Queenboro' Spit to the Queen's Bridge of the Sittingbourne and Sheerness Railway are vested in the trustees of the Queenboro' fishery. At the present time only a limited portion of this fishery is utilized, and this is rented from the trustees by a private oyster merchant. The operations of the lessee are confined to that part of the West Swale known as the Long Reach. Near the Queenboro' Causeway, on the foreshore of the town, are two oyster pits, and one of these is let with the fishery; there are also two other pits in the Long Reach, but neither these nor the one near the Causeway have been used within recent years. Over the area indicated, oysters—chiefly Portuguese and French—are laid down about April and despatched to the market as required, being dredged up direct from the layings and sent to Queenboro' station. That portion of the West Swale in which oysters are laid down is, even at low water, of considerable depth, in places, as much as 34 feet.

There are no sewers or drains very near to the oyster layings, the nearest possible sources of pollution being the sewage of Sheerness and Queenboro' on the west, and of Sittingbourne and Milton on the south-east. The Sheerness sewage is discharged on the ebb tide, between

MAP TO SHOW POSITION OF OYSTER LAYINGS IN THE MEDWAY AND ON THE NORTH COAST OF KENT.





Sheerness and the steamboat pier. The slop-water of Queenboro', a small town with a population in 1891 of 1,062, is discharged into a creek, a tributary of the Swale, running up behind the town.

Sittingbourne is for the most part a cesspool town, but about 20 per cent. of the waterclosets, and about 50 per cent. of the slop-water discharge into Milton Creek, a short distance from the town, by three separate outfalls. The sewage of Milton is discharged, untreated, into Milton Creek, near the outskirts of the town, and at Murston, a village on the eastern side of Milton Creek, about a mile distant from Sittingbourne, the slop-water of some 50 houses, including a few with w.c.'s, is discharged into the creek. Milton Creek, at low water, is of very small dimensions, and at this time the sewage and slop-water, above referred to, must form a considerable proportion of the whole volume. Fortunately the layings are over 4 miles from the mouth of the Creek.

The Anglo-Portuguese Oyster Company's Grounds. (Map, No. 23.)

This Company is, I am told, engaged in the trade of importing Portuguese oysters into this country from the River Tagus, where there are natural oyster beds extending landwards from Barricas, opposite Lisbon. The oysters from these beds are imported, from February to May, to oyster merchants in this country, and the oysters thus imported are either relaid in English waters, or distributed at once to the retailer.

This Company possesses the right of an oyster fishing over an extensive area in the Swale, extending from the Queen's Bridge, already referred to, to a little westward of Harty Ferry, and embracing the waters of the Windmill and Milton Creeks, and a portion of Conyer's Creek. From local inquiry, in the vicinity of these layings, I was informed that no oysters had been laid down by the Company in question for several years, although I am informed by the Secretary of the Company that it is proposed to use the layings at a future date.

At such times as oysters have been laid down in the Swale, I understand that the operations have been confined principally to that part of it near Fowley Island, off the mouth of Conyer's Creek. There are ebb-dry market pits just westward of Elmley Ferry hard, and there are wintering pits at Kelmsley Marshes, and near Peg Fleet.

Any question of pollution would obviously depend upon the exact locality in which oysters were laid down. It would not seem that oysters deposited near Fowley Island would be in much danger of any specific contamination, and the same remark would apply in a greater degree to the waters of Windmill Creek. Obviously, however, any oysters laid down near the mouth of Milton Creek would be in danger of encountering a considerable volume of dilute sewage.

The remainder of the Swale, eastward of the Anglo-Portuguese Company's grounds, and, indeed, as far out to sea as is represented upon the map, forms what is known as the Faversham Fishery. The oyster layings in this area are, however, at the present time, confined to two small portions, coloured green, both worked by the East Kent Oyster Fishing Company; the one, the Harty Shore Fishery, situated just westward of Harty Shore Ferry; the other, the East End Oyster Beds, situated just to the north of the Whitstable Company's oyster grounds. A certain number of "native" oysters are still dredged up over the grounds of the Faversham Oyster Company; the adult oysters being retailed by the dredgermen in the vicinity, the brood being sold for relaying to the East Kent Oyster Company. There are no drains or sewers near either of these layings, in fact, one of them, the last

referred to, is in what is practically the open sea, and in my opinion free from risk. The nearest pollution to the Harty Shore Fishery layings is the sewage of Faversham (population, 10,478), which enters the creek of that name just outside Faversham, and about $2\frac{1}{2}$ miles from the Swale, and the slop-water of some 35 houses at Oare, a village at the head of Oare Creek, about $1\frac{1}{2}$ miles from the Swale. At low water, Faversham Creek is but of very small dimensions and, near the outfall, it is not navigable, at this time, even by small boats.

The same remarks apply here as at Milton as regards risks of pollution; it is clear that oysters laid down or dredged up near the mouth of Faversham Creek would run risk of pollution from the untreated Faversham sewage.

THE OYSTER FISHERIES IN THE RIVER MEDWAY. (Map, No. 23.)

The fishing in this river, below Rochester, save in some of the creeks, is vested in the Corporation of Rochester, and it is to the Town Clerk of this Borough that I am indebted for information as regards the distribution of oyster layings here. At the present time there are but four oyster layings in connexion with the Medway, and even these are for the most part remote from the main channel of that river, being situated in creeks on the salt marshes on either side of the estuary. A reference to the map will show there are at the present time no oyster layings within many miles of Rochester Bridge.

The Ham Ooze Oyster Layings.

These layings are situated alongside the Medway Saltings, near a branch of the estuary known as "Half Acre." As in the case of the other layings just described, foreign oysters are laid down, and these, when ready and required for market, are despatched by boat to Gillingham.

Colemouth Creek Layings.

Situated on the north side of the river Medway, about a mile westward of Port Victoria, this creek affords layings for a large number of oysters, partly foreign, partly English. When required for market the oysters are despatched by train, either from Port Victoria or Lower Stoke.

Sharfleet Creek Layings.

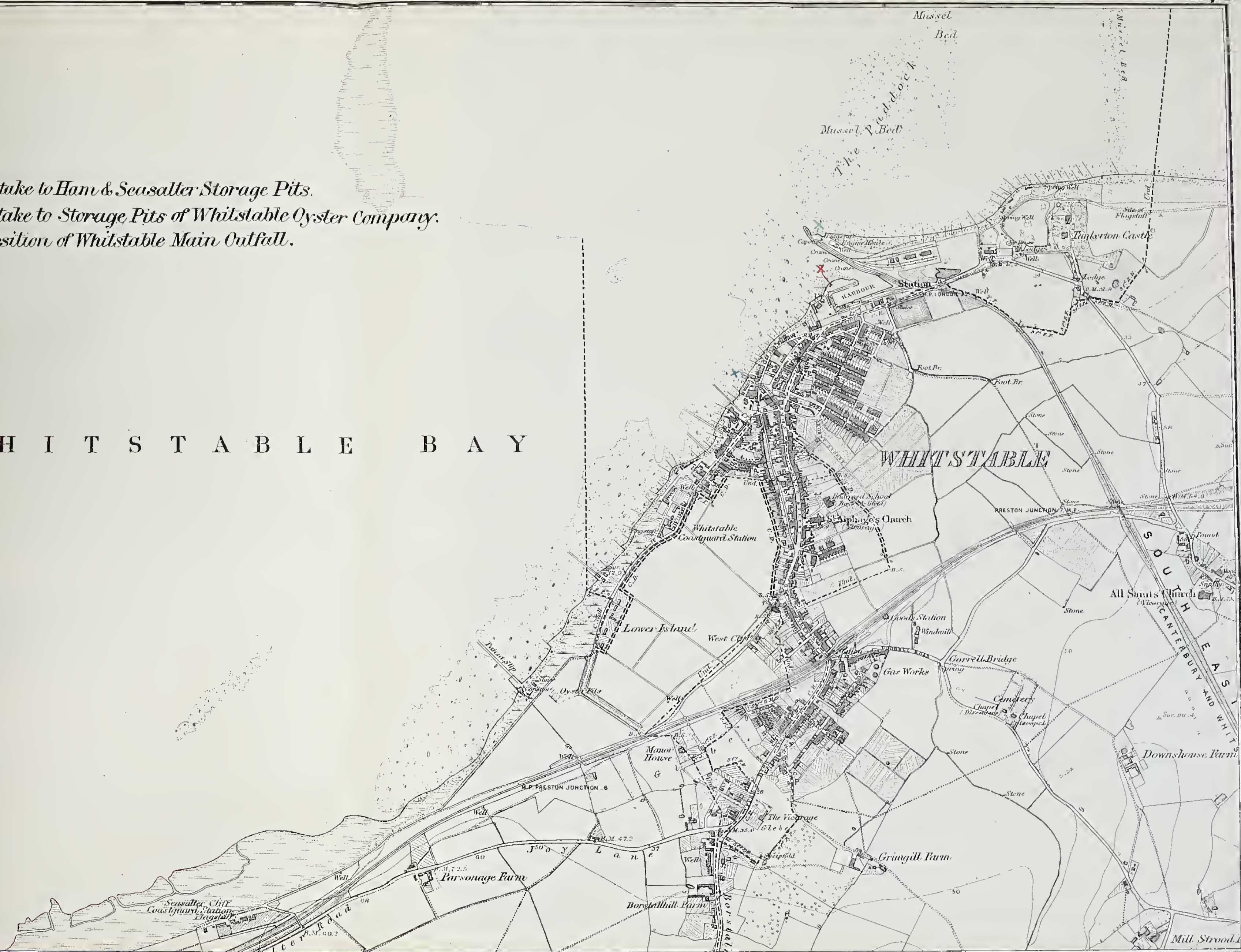
This creek is practically a branch of Stangate Creek, the fishing in it being leased from the Corporation of Rochester. The actual layings occupy but a portion of the creek, *i.e.*, that to the westward; on the marshes alongside the layings, are wintering pits. Oysters required for market are despatched *viâ* Rainham Station.

Stangate Creek Layings.

These layings are leased, not from the Corporation of Rochester, but from the Lord of the Manor. The extent of the fishery embraces the whole length of the Creek from its junction with the Medway to its inland extremity; but in actual practice there are, I am informed by the local manager, no oysters laid down within $1\frac{1}{2}$ miles of the mouth of the creek, from which point the layings extend inland to Funton Creek, and other creeks thereabouts. Over the area indicated foreign oysters

- x = Intake to Ham & Seasalter Storage Pits.
- x = Intake to Storage Pits of Whitstable Oyster Company.
- x = Position of Whitstable Main Outfall.

WHITSTABLE BAY



are laid down in the spring of the year, and endeavours are, as a rule, made to sell out all such oysters by Christmas, so as to avoid the risks which exposure to frost might entail. There are now no wintering or storage ponds in the locality of these layings; formerly both were used but no advantage seemed to accrue therefrom. Such foreign oysters as are not sold by the beginning of winter are sent down to the layings belonging to the lessee in Falmouth Harbour. Oysters from the Stangate Creek layings are, when required for market, packed up and despatched *via* Sittingbourne Station. A considerable number of these oysters are, however, sent to Ostend.

As regards the main pollutions of the Medway from Rochester downwards, it is necessary to mention that the three towns of Rochester, Chatham, and Gillingham are, in regard to their sewage disposal, what are known as cesspool towns, *i.e.*, the liquid refuse is disposed of in cesspools. I am informed, however, by Mr. W. Watson, the Medical Officer of Health for Rochester Urban and Port Sanitary Districts, that in the town in question the sewage of several Government establishments goes direct into the Medway, and that there are also in parts of the town numerous overflows from cesspools into the surface drains.

At Chatham, Dr. Holroyd, the Medical Officer of Health, tells me that although the disposal of both slop water and sewage proper is mainly by means of cesspools, he estimates that, roughly speaking, about one-sixth of the sewage finds its way into the river.

Gillingham is, I am told by the Medical Officer of Health, entirely a cesspool town, and that there are here no overflows from cesspools into surface drains. A scheme for sewerage this town, and for passing the effluent, after treatment, into the Medway, is now under consideration.

The oyster layings in the Medway are situated in positions quite remote from habitations, in fact, in positions which are by land very difficult of access. In three instances the layings are far removed from the channel of the river, and appear to me to be practically free from risk of sewage pollution. In the fourth case the laying, though not so remote from the channel, is nevertheless, I think, so far removed from sources of pollution as to be out of serious danger.

As regards these layings, it must, I think, be held that they are largely protected by their position and the enormous volume of water in the Medway.

* Mr. William Watson, Medical Officer of Health to the Rochester Port and Urban Sanitary Authorities, states in his annual report for 1894, "As certain cases of typhoid fever have been attributed to the eating of oysters, and such statements are calculated to injure the sale not only in our markets but in London and elsewhere, I think it is only fair to say that the Medway beds are in my opinion still to be trusted as they lie wide of the tidal stream."

SUMMARY as to the OBSERVED RISKS of SEWAGE CONTAMINATION of
OYSTERS LAID DOWN or STORED around the ENGLISH and WELSH
COASTS.

It will have become apparent from the detailed account that I have given of the conditions under which the oyster industry is carried on in one and another locality of the coasts, that, as regards the risks of specific, or, for that matter non-specific, pollution of oysters, layings used as fattening beds, and storage ponds, are the places to which attention needs to be more especially directed.

This being the case, the position of such places has, in descriptions of the local oyster industries, received the fuller attention, and maps have in the majority of cases been furnished showing the position of fattening beds and ponds in relation to the sewer and drain outfalls. It must have been apparent from these descriptions and maps that at certain places along our coasts no care whatever has been exercised in the selection of localities for layings serving as fattening beds and for storage ponds, in order to ensure that oysters in these places should be reasonably free from risk of sewage pollution; and also it will be clear that considerations of accessibility and convenience have, in many instances at least, determined the selection of storage ponds, fattening beds, and layings. A general view of the conditions will have served to demonstrate that many of the larger and more important oyster companies possess "layings," fattening beds, and storage ponds in the main free from the risks of dangerous sewage pollution; and that, moreover, where security in this sense does not obtain, it may—in not a few instances, at least—be easily brought about by the simple expedient of altering the position of the fattening beds or storage pits. But, on the other hand, it will have been obvious to the reader that there are cases where the risk of sewage pollution to oysters is so great and so undeniable, that nothing short of complete diversion of the sewers or drains, or withdrawal of existing fattening beds or ponds from use, can be regarded as satisfactory in the public interest. It would indeed appear that, in several places along our coasts, the conditions are at least equally bad, if not worse, than those which are reported to have brought about the very remarkable outbreak of enteric fever at Wesleyan College, Connecticut, U.S.A. (*see* Appendix, No. 3.).

Speaking in general terms it has to be said that in the past the proximity of sources of pollution has not been taken account of in selecting places for the laying down or storage of mature oysters; and that, therefore, restrictions and regulations which, to be of use, should be retrospective in effect, are necessary in order that the oyster industry may be carried on in future without subjecting oysters destined for use as food at an early date to danger of contamination with sewage matters.

In making the above statement I am desirous not to exaggerate the risk of contamination of oysters in the above sense, which the topographical relation of sources of pollution and oyster ponds or layings may now and again seem to suggest. Obviously it is possible to reduce to an absurdity the demand for absolute freedom of food supplies from such risks; and to regard, for instance, all articles of food exposed to the ordinary atmospheric conditions of towns as liable to specific contamination, more especially if regard be had to the somewhat cosmopolitan distribution of *bacillus coli*. As regards oysters, it would be not difficult to argue that even the deep-sea oyster beds may in theory not be entirely free from risk of dangerous contamination. In

prosecuting my inquiries, however, certain general considerations have been borne in mind.* For instance, when sewage is allowed to enter an estuary near to its junction with the sea, it is possible that, if the sewage be liberated during only the early ebb of the tide, it may be carried well out to sea, so that none of it will return on the flowing tide to the estuary. If, on the other hand, the sewage be allowed to discharge during the whole of the ebb tide it is clear that some of it will be carried back on the flowing tide above the outfall; and when neap tides are giving place to spring tides, that such of the sewage as floats on the surface may be carried a considerable distance up the estuary. Where, again, the outfall is at such a distance from the mouth of the estuary that sewage liberated, even on the first of the ebb, fails to pass out to sea before the flow of the tide commences, it will be clear, having regard to this one fact alone, that some sewage will be carried up and down the river almost indefinitely. It is, indeed, this *tidal oscillation*, resulting, from frequent additions, in an accumulation of dilute sewage, which forms what is known as the *sewage zone*. The movements of sewage in an estuary are, however, not so simple as the above considerations might seem to indicate, and it is necessary to bear in mind that sewage is composed partly of solids and partly of liquids. There is, as a general rule, a variable amount of fresh water entering the estuary at its head and sides, and this influx of fresh water gives rise in proportion to its volume to a gradual displacement of sewage at the mouth of the estuary. It must not be supposed that there is any hard-and-fast line to be drawn between the fresh and salt water, or between the sewage and the water of the estuary. When liquids of different specific gravities meet in the tideway, a condition which may be experimentally illustrated by differently coloured liquids, there takes place, owing to the tidal movements, what is known as a *mixing* action, by means of which salt water may find its way for many miles up a river, against the direction of the river's flow; and it is owing to the complications resulting from this *mixing* process that the movements of neither deep or superficial floats form a trustworthy index of what will be the movements of sewage. It must, of course, be said that where floats go, there floating portions of sewage may go, but it would be altogether unsafe to conclude that where floats do not go, there no sewage can find its way. In addition, there are other considerations which must be held in view in estimating the liability to pollution by sewage of oyster layings.

There is a tendency towards the sedimentation or deposit of sewage matter, together with the micro-organisms it contains, which has the effect of very materially cleansing rivers as they proceed on their course, and this tendency is the more apparent during the slack periods of the tides and in quarters affected by the backwaters of currents and eddies. There are, too, the effects of oxidation, and the influences of sunlight, and of animal and plant life, to be taken account of.

It must also be borne in mind that the proximity to oysters of sewage outfalls can only be taken as a rough index of the risks to the former of *specific* contamination. There are questions of the composition of the sewage, which it is necessary to consider; such, for instance, as to whether excrement disposal in a given locality is by means of cesspools or privies, or by means of waterclosets connected with the public drainage system.

* See First Report of Royal Commission on Metropolitan Sewage Discharge (Eyre & Spottiswoode, 1884); also paper on the "Horizontal Range of Tidal Rivers, such as the River Orwell," by Charles Foote Gower, M.Inst.C.E. Minutes of Proceedings of the Institution of Civil Engineers, Vol. lxxxvi. Session 1885-86. Part iv.

The vitality of the enteric fever bacillus and of the cholera vibrio in sea-water and in water of different composition and degrees of salinity, has obviously an important bearing upon this question of risks of specific pollution of oysters in the tideway, but it will doubtless be accepted as demonstrated by Dr. Klein, that there is no such immediate disinfectant action possessed by sea-water as was formerly assumed, and that, therefore, persons who place oysters near to sewage outfalls in this belief have no sufficient justification. It seems, however, clear that there is not in sea-water much tendency to *multiplication* on the part of the enteric fever bacillus or of the cholera vibrio, and, further, that the vitality of these organisms is not indefinitely maintained there. These facts have a very material bearing upon those instances where oyster layings, though in an estuary which at part of its course receives sewage, are nevertheless so far removed from sewage outfalls as to render it doubtful how far enteric fever or cholera germs can reach them in a condition of viability.

Lastly, there is the question of *dilution*, and in dealing with some of the large estuaries, such, for instance, as the Blackwater, in Essex, this consideration must be allowed the weight due to it in estimating the effect of pollutions in endangering oysters, although it must at the same time be borne in mind that sewage is frequently turned, not into unpolluted water, but into water already impregnated with sewage, which, through the agency of some of the forces already referred to, has accumulated in the vicinity of the outfall. It is obvious that where oysters are laid down for the purposes of fattening or for storage near to a sewer outfall, there considerable risks must obtain of their contamination by sewage, and that the degree of risk which they incur of specific pollution must correspond in some degree to the method of excrement disposal adopted in the locality and to the prevalence of waterborne diseases therein.

MUSSELS.

The edible mussel (*Mytilus edulis*, L.) is, like the oyster and cockle, one of the *Pelecypoda* or *Lamellibranchiata*, and, by virtue of its possessing two adductor muscles, which in this case are unequal in size, it is said to belong to the *Heteromyarian* division of this class.

The mussel, like the cockle, possesses a plough-share shaped "foot," a muscular protrusion of the ventral surface, which is moved by means of one protractor and two retractors. At the base of the "foot" is the gland known as the "byssus gland," which furnishes a filamentous secretion by which the mussel moors itself to rocks, stones, ships,* or fellow mussels. The mechanism and methods of thread spinning are very similar to those of the spider: the viscid secretion of the byssus gland runs into a groove of the foot by means of which it is, as it were, cast into threads, and the movement of the foot effects the anchorage of the thread to adjacent objects. In the case of the *Pinna* (Fam. *Aviculidæ*) the byssus, is very voluminous in extent, and is used in some places for articles of apparel, such as gloves, which are sold at fancy prices.† The mollusc can easily detach itself from any object and become again attached, and, if removed by force, it will soon be found to have effected a fresh anchorage.‡ The mussel is thus able, in some degree, to change its environment, and, in this respect, it differs from the oyster, which, in the adult state, is quite stationary. The respiratory, digestive,§ circulatory, and secretory systems of the mussel are, in principle, similar, both morphologically and physiologically, to those of the oyster, and a detailed description will not, therefore, be here given. As with the oyster, so with the mussel, it appears that it is unable to exercise any great selective power in the matter of food; it consumes, in other words, such minute animal and vegetable organisms as exist in and are brought by the water which passes over its branchial filaments. Mussels are said to be very sensitive to cold weather. It is recorded in "Molluscs and Brachiopods" (Cooke, Shipley, and Reed) that in 1874, during an easterly gale, 195 acres of mussels at Boston, in Lincolnshire, were killed in a single night. In estimating, however, the effect of a storm on mussels, regard must be had to the amount of sand deposited in the branchiæ of the mollusc.

The sexes of the mussel are separate, *i.e.*, ovaries and testes occur in different individuals, and the young mussel passes, like the young oyster, through a pelagic phase of existence. During the spawning season the sex of the mussel may usually be distinguished by the difference of colour which each presents, the mantle of the male at this time being of a reddish-yellow appearance, that of the female a deep red. The edible mussel has a very extensive geographical distribution, and a detailed description of each mussel bed, scalp, or "lay" in this country, is hardly within the limits of practicability.

* The bottom of the *Great Eastern* steamship was at one time so thickly coated with mussels that a vessel of 200 tons could, it was thought, have been laden from her. (Molluscs and Brachiopods.—Cooke, Shipley, and Reed.)

† The U. S. Commission of Fish and Fisheries, Part XX., by Ernest Ingersoll. Lovell's Edible Mollusca.

‡ For an account of some experiments relative to this point, see report for 1895 on the Lancashire Sea Fisheries Laboratory at University College, Liverpool, by Prof. W. A. Herdman, D.Sc., F.R.S., and Mr. Andrew Scott, Fisheries Assistant.

§ In the intestinal tract of the mussel, as, indeed, in that of the majority of bivalves, there is often found what is known as the *hyaline* or *crystalline stylet*. There is some difference of opinion as to the significance of this stylet. Möbius, for instance, regards it as a reserve of food material, while Schulze thinks that it protects the intestine from laceration ("Molluscs and Brachiopods," by Cooke, Shipley, and Reed).

Until quite recently there were no restrictions over the mussel beds of England and Wales, and broadly it might be said that, wherever mussels could be found, there they might be taken. In places, however, where "regulating" or "several" orders of the Board of Trade are in force under the Sea Fisheries Act of 1868, restrictions as regards mussels have been exercised, while at the present time the Sea Fisheries Committees, constituted under the Sea Fisheries Act, 1888, have, for the most part, issued byelaws for controlling the mussel fisheries in their district. Such byelaws, however, relate in the main—

- (a) To prohibiting the taking of mussels under a minimum size, usually 2 or $2\frac{1}{4}$ inches;
- (b) To a close time, which is, as a rule, the whole or part of the period embraced by the months, May, June, July, and August.
- (c) To the separation of the mussels from one another; and
- (d) To putting back upon their bed all mussels under the size allowed to be taken.

The byelaws in force at the present time do not prohibit the taking of mussels from the vicinity of sewer outfalls and other undesirable situations.

As a general rule mussels are procured from the "scalps" and despatched direct in sacks or bags to the market. The methods adopted for the gathering of mussels vary in different localities according to whether the mussels become dry on the ebb tide or are always covered with a certain depth of water. In some instances dredges, similar in construction to those used for oysters, are employed; in other instances, rakes, fitted with long wooden handles, sometimes 30 to 40 feet in length, are used, having at the back of the rake, and at right angles to the direction of its teeth, a short piece of netting to prevent the mussels from falling off; or the rake is fitted with a bag of netting into which the mussels fall. Some such rakes as these are common in estuaries like those of the Conway and the Tees, where even at low tide the beds in the Channel are covered with many feet of water, while rakes with shorter handles are used in shallower estuaries such as the Exe and the Teign in South Devon. The size of the rake and the interval between its teeth are matters often regulated by the byelaws, and it may also be enacted that when the mussel beds are covered by a minimum depth of water, rakes alone are to be used in collecting the mussels—a precaution calculated to prevent the trampling in and damaging of the mussels by the gatherers. When the mussel beds dry at ebb tide, hand picking is freely resorted to, but this method is liable to damage the mussel beds very materially from the amount of trampling which it necessitates.

There is at the present time a demand in this country for mussels, whether for bait* or food, which is in excess of the supply, and the markets have in consequence to be supplemented from the Netherlands (especially North and South Holland), Hamburg and Ireland. As an instance of the amount of mussels used for bait, it may be recorded that during the three years 1885, 1886, and 1887, it was estimated by Mr., Dowel, the fishery officer for Berwick, that no less than 242,828,250 mussels were used in the haddock fishery at Eyemouth, the value of the mussels being estimated at 7,664*l.*, and the value of the fish caught by them 58,940*l.* The diminished home supply of mussels, though perhaps in part apparent only, is regarded as being due to the reckless exhaustion of

* Those interested in the subject of mussels as bait will find much interesting information in the report of the Committee appointed by the Secretary for Scotland to inquire into the condition of the Mussel and Bait Beds.

the beds, owing to the unrestricted gathering of the mussels. It is considered that the restrictions embodied in the regulations and byelaws referred to above will have in time the effect of increasing the supply of marketable mussels whether for the purposes of bait or food. In this connexion it has to be noted that the practice of laying down young "seed" mussels, very much in the same manner as that referred to when the subject of oysters was under consideration, has been in vogue for many years, and is at the present time being considerably extended.*

"Seed" obtained from the natural beds is laid down in such situations as are thought to be, or have been proved by experience to be, suitable; and they are there allowed to grow and fatten until they become marketable. If the mussels are laid down in a suitable environment they grow and fatten more rapidly than if left upon the beds; mussels seem, indeed, like oysters, to spat well in salt water, but to grow and fatten best in localities where they are at times exposed to brackish water only, *i.e.*, sea water mixed with upland fresh water. Furthermore, the tending which the mussels or "lays" receive affords them better opportunities for unrestricted growth, and enables them to be kept free from their natural enemies, such as starfish and whelk tangles.

There is also another practice common among fishermen who bait with mussel, of storing up such as are suitable for bait in secluded spots upon the sea shore, or in estuaries, there to be accessible as they are required. On some coasts it is difficult to discover such secluded spots, and the hope of the fishermen is that a spell of fine weather may follow the deposit of these mussels, sufficiently long to allow them to effect an anchorage by means of the filamentous secretion with which they are furnished, since otherwise the next storm may effect their removal.

In addition to the system of mussel "lays," *i.e.*, the bed system, which is increasing in favour in this country, there are some prospects that the Bouchot,† or wattle system of mussel culture which has been attended with such good results in France may be adopted in certain places. This system had its birth in the Bay of Aiguillon‡ on the west coast of France, and was the invention of an Irishman named Walton, who suffered shipwreck in the bay near the village of Esblandes in 1235, and was rescued by the inhabitants. Walton had an inventive mind, and, amongst other things, he crossed the sheep of the district with some that had been saved from the wreck, and also invented a net, the *alluret*, which he used for catching such birds as skim the surface of the flats by night. These nets were supported by a system of poles fixed in the mud of the foreshore of the bay, and Walton, during his operations with the nets, noticed that the poles became covered with mussels; he increased the number of poles and thus began what is known as the *bouchot* system of mussel culture.

The system, as carried out by Walton, consisted in arranging rows of poles on the foreshore in V shaped forms, the apex of the V being seaward; the intervals between the poles were bridged with wickerwork, and a space was left at the bottom to prevent the silting up

* For an interesting account of the bedding system of mussel culture, see paper on the History of Mussel Culture at Montrose, during the past six years, by J. H. Fullarton, M.A., D.Sc., F.R.S.E., in the thirteenth annual report of the Fishery Board for Scotland.

† A word stated by M. Coste to be formed by contraction from *bootchoat*, an expression derived from a mixture of Celtic and Irish, and signifying a wooden enclosure; *bout* enclosure and *choat* or *chot* of wood.

‡ See "Rambles of a Naturalist," by M. de Quatrefages. "Edible British Mollusca," by Lovell. "Guide Pratique de l'Ostréiculture," par M. Felix Fraiche,

of mud. The rows nearest the sea caught the mussel spat, those higher up towards the land were used for growing them. Walton also invented a flat-bottomed boat for traversing the muddy foreshore where the *bouchots* were erected; it was known as the "*acon*," and similar boats are used to-day in the industry. The Bouchot system, as carried on in France at the present time, is in principle identical with that practised by Walton, save that there appears to be now a tendency to erect the rows of posts parallel to one another, instead of, as formerly, inclined at an angle. The *bouchots* furthest removed from the shore, and which are uncovered at low water of spring tides only, are called by the "*boucholeurs*" *bouchots du bas*, those near the shore *bouchots bâtards*, and those highest up, which are for the longest period out of the water, *bouchots d'amont*.

The *bouchots du bas* consist of posts only, and may be regarded as solely collectors of spat. It is from these posts that about the month of July, when the young seed mussel has acquired the size of a haricot bean or thereabouts, that the ordinary letters obtain the supply of mussels necessary to furnish the landward *bouchots* with. The young mussels are separated from the posts, wrapped in pieces of old netting and pushed in between the interstices of the wattling; the netting decays and leaves the mussels attached to the wattling. Trial has been made of *bouchots* in several places in Scotland, such as Montrose, Tain, Inverness, and St. Andrews, but it does not appear from the accounts of those experiments, which were given before the Mussel Bait Commission in 1888 that these attempts have been attended with any great success; much difficulty seems to have been experienced in rough weather.

Although, as has been stated, the ubiquitous distribution of the mussel around our coasts precludes anything like detailed reference to the beds, some of the chief centres of supply may be here indicated.

On the East coast, "the slakes," near Holy Island in Northumberland, and at Budle Bay a little southward of this, furnish a limited supply of mussels, and recently the bed system of mussel culture has been considerably extended thereabouts. In the River Blyth in the same county there are also natural mussel beds, though these are much less extensive than in former years, and in this river attempts at the bed system of mussel culture have also been made. From the estuaries of the Tees, the Esk, and the Humber—especially the first named—mussels are procured, but the extensive beds in the mouth of the Tees, which in former years furnished much of the East coast with bait, as well and provided a considerable supply for food, have, it appears, undergone a marked decay, owing in part, it is said, to dredging operations, and in part to unrestricted gathering. From the Wash, where there are numerous mussel scalps, under the jurisdiction partly of the Corporation of Lynn and Boston and partly of the Eastern Seas Fisheries Committee and the grantees of the le Strange Fishery Order, 1882, large quantities of mussels, both for bait and food, are obtained; as also "seed," much of which is laid down to grow and fatten on the Norfolk coast at such places as Brancaster, Burnham, Wells and Blakeney. From the coast of Essex extensive supplies of mussels brood are procured, and much of which is laid down again in the mouth of the Thames near to Southend and Leigh. The north coast of Kent, and the estuary of the Medway, furnish considerable supplies, and "seed" obtained from the Kentish flats and elsewhere is laid down in suitable spots in the River Medway, and, at times, exported in large quantities to Holland for growth. On attaining to a marketable size, much of it is re-imported into England. At times, mussels from the "flats" referred to are used for the purpose of manure.

On the South coast mussels are procured amongst other places from Shoreham in Sussex, from the Hampshire coast, and from the Teign and the Exe in Devon. Padstow on the North coast of Cornwall, and Swansea and Carmarthen Bay on the South coast of Wales, furnish supplies to the districts thereabouts. On the West and North Welsh coasts, the estuaries of the Dovey, Mawddach, Conway and the Foryd, especially the Conway, furnish together a very considerable supply, while on the Lancashire coast natural beds and mussel "lays" are found at Fleetwood near the mouth of the River Wyre, as well as off Heysham, Morecambe, Piel, and other places in and around Morecambe Bay. In Cumberland, mussels are found in the Esk and other localities.

There is less need for discussing the liability of becoming fouled by sewage to which mussels may be subjected, since by far the greater proportion of mussels, whether grown in this country or imported from abroad, are either used for bait by the small-line fishermen or are eaten after having been cooked. In so far as this fact tends to remove mussels, and other "shell fish," from the position which it is necessary to regard oysters as occupying in this respect, the risk of water-borne diseases being conveyed through this agency is reduced in a very material degree, seeing that before being eaten they are presumably sterilized in so far as the organisms of cholera and enteric fever are concerned. Still, there are the consumers of uncooked mussels to be considered; and, even for cooked mussels, it is inexpedient that they should be procured for human food from near the outfalls of sewers, or from other undesirable situations.*

That there is need for some control of the mussel industry, in so far at least as mussels intended for human food are concerned, is a fact which may perhaps be illustrated by recording instances wherein these molluscs have come under suspicion as having been of the means of conveying enteric fever.

In 1883 Dr. M. K. Robinson, Medical Officer of Health to the East Kent combined Sanitary Districts, records, in his annual report to the Broadstairs and St. Peter's Urban Sanitary Authority, two cases of enteric fever which were apparently contracted from the consumption of uncooked mussels procured from near the outfall of the Ramsgate sewer. Some of the mussels in question were eaten by the sister of one of the sufferers, and she was shortly afterwards attacked with vomiting and diarrhoea, but failed to develop enteric fever. Commenting upon these cases, Dr. Robinson aptly observes, "If milk and water can act as a vehicle for the conveyance of enteric fever contagion, which is known to be the case, there is nothing unreasonable in believing that mussels gathered at the mouth of a sewer and consumed in a raw state might prove also capable of communicating the disease."

Dr. F. Cecil Piggott, Medical Officer of Health for Teignmouth, recorded in 1894 certain cases of enteric fever as to which the evidence pointed to mussels or cockles obtained in proximity to the outfall drain of the Infectious Diseases Hospital, as having been the means by which the disease was contracted. Dr. Piggott adds, that under the circumstances which obtained at the Fever Hospital during the time to which his observations relate, it was impossible to rest assured that the excreta from enteric fever patients was efficiently disinfected. From a personal inspection of this locality I am able to agree that mussels procured thereabouts must be in danger of becoming fouled by specifically infected excreta.

In 1894, 1895, and 1896, Dr. Newsholme, Medical Officer of Health for Brighton, reported to the Sanitary Authority of that borough

* It is doubtful whether in some methods of "cooking" mussels a sufficiently high temperature is reached to destroy the micro-organism of enteric fever or cholera.

cases of enteric fever which he regarded as having in all probability been contracted by the consumption of raw mussels procured from a river to which sewage has access; and in a paper which is to appear in Vol. XVII. Part III. of the Journal of the Sanitary Institute, Dr. Newsholme has set out very clearly facts and arguments in support of his views.

Again in 1895, uncooked mussels procured from certain mussel beds in the River Blyth in Northumberland, situated near to the sewer outfall of an infectious disease hospital, came under suspicion as having been instrumental—in the opinion of the Medical Officer of Health of the district where the cases occurred—in conveying enteric fever. Here again local inspection and inquiry showed that mussels were at times procured in dangerous proximity to the hospital sewer.

Apart, however, from the consideration of the conveyance of enteric fever through the agency of mussels, it is essential to make reference, while discussing these molluscs, to the numerous instances on record where their consumption has been followed by other serious illness which has now and again proved fatal.

The symptoms of the malady referred to begin shortly after the consumption of the mussels; in some cases but 10 minutes has elapsed, in others 24 hours. With respect to the quantity of mussels eaten; in some instances large numbers have been consumed, in others one mussel has sufficed to produce illness; indeed, it is recorded by Möhring in the German Ephemerides,* that a person attacked swallowed only the liquid portion of a mussel which he had chewed.

The more usual symptoms consist of epigastric pains shortly followed by diarrhœa and vomiting, by an urticarial rash over the whole or part of the body, and by swelling of the eyelids accompanied by coryza. There is often tingling of the lips and a dryness of the mouth and throat, leading to a feeling of constriction; and also at times loss of muscular co-ordination amounting occasionally to absolute paralysis. As a general rule the mind remains clear, but cases are on record where complete insensibility has supervened. In some cases a powerless condition of the limbs seems to have been the first indication of mischief, and in one case paralysis of the respiratory muscles occurred.†

Such being the more prominent symptoms of mussel poisoning, it will be of interest to pass briefly in review the several theories which from time to time have been held to account for them.

In many instances the symptoms are best explained by reference to the peculiar personal equation, the idiosyncrasy, of the consumer, a view which receives support from a consideration of instances in which several persons have simultaneously partaken of mussels procured from the same locality, and where certain persons, perhaps members of the same family, have alone become affected.

In addition, however, to instances of this sort there are others, where all those, perhaps of different ages and different families, persons who have frequently eaten mussels with impunity before, have become attacked almost simultaneously after consuming mussels derived from a particular locality. These instances would seem conclusively to indicate that there are often other factors involved than those of idiosyncrasy and that mussels are at times both *absolutely* and *relatively* poisonous.

It has been thought in the past, and indeed it is still popularly believed, that the poisonous property of the mussel resides in the branchiæ or gills of the mollusc; but this view of the question is quite inadequate to explain all the observed phenomena, inasmuch as mussels

* See Christison on Poisons.

† See Lancet, September 29, 1888.

from which the branchiæ have been carefully removed have still been potent for harm in the sense of causing symptoms of poisoning.

What may be called the "Copper Theory" has for many years held a prominent place in explanation of the symptoms described, it having been believed that the mussels have the power of taking up, in one form or another, copper from the docks, or from ship's bottoms, in or upon which they have become attached. This view, although still widely prevalent, is unsupported by any satisfactory evidence. In the calamity which occurred at Leith in 1827, and to which further reference will shortly be made, Dr. Christison* analysed some of the mussels derived from the stomach of one of the persons attacked, but was unable to detect a trace of copper therein, and it is clear by reference to the literature of the subject that in many cases no copper could have gained access to the mussels.

Again it has been thought that the presence of a small crustacean, known as the *Pinnotheres pisum*, within the branchiæ of the mussel has been responsible for the symptoms, but here again the evidence adduced is quite insufficient to support the contention.

It has likewise been alleged that mussels which have caused untoward results have been stale or dead; but although putrefactive changes may have produced symptoms of poisoning in certain cases, it is clearly established that in many of the most pronounced cases the mussels were quite "fresh."

So, too, with regard to a belief that the poisonous properties are due to the spawn of the starfish, it has been shown that mussels taken from localities not frequented by starfish were nevertheless capable of producing definite symptoms of poisoning. It is, however, by no means improbable that in some cases the poisoning may have been due to the contents of the mussels intestinal tract.

Lastly, there is no evidence to support the allegation that only during the spawning season are mussels harmful: indeed, it has been shown in France that the supposition has no foundation, and on exhaustive inquiry the prohibition which formerly obtained against taking mussels during the spawning season has been rescinded.

In 1885 there occurred at Wilhelmshaven a remarkable and highly instructive outburst of mussel poisoning, which was instrumental in contributing much to our knowledge upon the subject. The mussels which caused the mischief were procured from the bottom of two vessels anchored in the waters of the port, and were consumed while still quite fresh by some of the labourers in the arsenal. Nineteen hours afterwards those who had partaken of the mussels were attacked, and a few hours later four of those attacked died. It was remarked that some animals which had also eaten of the same batch of mussels quickly succumbed.

The outburst was examined into in one or another of its aspects by Brieger, Max Wolff, Salkowski, Schmidtman, Virchow, and others. Wolff demonstrated that the toxic principle resided in the liver, while Brieger succeeded in obtaining from the liver a powerful alcoholic extract, which he regarded as a ptomaine developed under the influence of a special microbe, which ptomaine he called *Mytilotoxine*, and assigned to it the definite formula of $C_6 H_{15} NO_2$. Salkowski made the interesting discovery that the alcoholic extract referred to above became inactive when treated with *carbonate of soda*, and that mussels boiled for some six minutes in a solution of this salt lose

* Christison on Poisons.

their toxic properties. This fact would appear to afford valuable indications for treatment in cases of mussel poisoning. It has also been determined by Virchow that poisonous mussels kept in an aquarium for two months or thereabouts cease to possess toxic properties. M. Dutertre* has apparently obtained very similar results, and found that the poison extracted from the liver acted in a similar fashion to curare. Sir Charles Cameron, Medical Officer of Health and Public Analyst to the City of Dublin, investigated in 1891 an occurrence of mussel poisoning, to which reference is made later, and from which the results obtained were apparently very similar to those found by Brieger and Dutertre. Sir Charles Cameron was inclined to regard the liver of the mussels as diseased. Some of the Dublin mussels were examined in their bacteriological aspect by Dr. E. G. McWeeney who succeeded in isolating from the liver an organism which he regarded as having possibly furnished as one of its metabolic products a poisonous leucomaine or albumose which may have caused the symptoms observed. Dr. McWeeney's note† is, however, only provisional, and he therefore speaks very cautiously as to the results obtained. Lustig has studied the subject of mussels from the viewpoint of their action on the animal economy. He was able to discover no microbes in mussels taken from the open sea, but from those taken from docks and stagnant pools he isolated two organisms, one benign, the other pathogenic; this latter introduced into the digestive canal of animals produced death in one or two days.

There is still obviously much to be learnt as to poisoning by mussels, but the view which is at present held is that the effects are due to *Mytilotoxine*, a poison produced by the agency of bacteria, which have, as a rule, been conveyed to the mussels through the sewage pollution of the water in which they have grown or have been placed.

Whether or not the above explanation is adequate to account for all the cases of mussel poisoning which have been observed, it seems clear from a perusal of the literature of mussel poisoning that in a large number of instances the harmful mussels have been procured from situations to which sewage or other forms of filth have had opportunity of gaining access. This fact will become apparent from a brief reference to some of the more notable instances of mussel poisoning on record.

In 1827 some thirty persons were severely affected—in two cases fatally—after eating mussels taken from the dock gates at Leith, and animals (a cat and dog), to which some of the mussels were given, were likewise affected. The outbreak is very fully reported upon by Dr. James Combe, in Vol. XXIX. of the Medical and Surgical Review.

In the British Medical Journal for Aug. 1, 1857, is recorded the poisoning by mussels of a ship's crew at Hartlepool. The mussels in question were procured from the lower part of a dock wall.

In 1860,‡ a number of persons at Tralee were attacked after eating of mussels taken from the bottom of a ship canal.

In 1862 a woman died as the result of the ingestion of mussels taken from a ship in a certain dock at Birkenhead. Several other persons who ate of the mussels were attacked.§

In 1872, a man aged 31 died from poisoning as the result of eating mussels obtained from some dock gates. The mussels were eaten on a Saturday night, and the patient succumbed on the Sunday morning

* British Medical Journal, October 1, 1887.

† "Preliminary Note on the Bacteria of Poisonous Mussels," British Medical Journal, October 3, 1891.

‡ "The Principles and Practice of Medical Jurisprudence," Vol. I., edited by Stevenson.

§ British Medical Journal, 1872, Vol. II., p. 591.

following. Three men and a boy ate upwards of two score mussels from the same source without being affected, but a brother of the deceased who ate some of the mussels was seized with symptoms of poisoning.

In 1880 a girl, aged 7 years, who ate mussels gathered from the quay at Port Glasgow, succumbed with symptoms of mussel poisoning.

In Vol. 3 of the London Medical Repository, are recorded, by Dr. G. M. Burrows, two cases of mussel poisoning which occurred at Gravesend. Two boys, aged 9 and 14, ate mussels which were apparently dead and which had been gathered from the bottom of a ship.

In 1885 the well-known Wilhelmshaven cases occurred. As has been already remarked the mussels were procured from the bottom of two vessels in the harbour. It is said that the mussels though "fresh," enhaled a disagreeable odour.

In 1880,* Dr. M. K. Robinson reported that two persons who had gathered mussels near to the Ramsgate sewer outfall were attacked with symptoms of poisoning; and, in 1889, illness was traced to the consumption of cockles procured from the same locality.

In 1888 three cases of mussel poisoning occurred at Liverpool, the mussels having been procured from the bottom of a vessel located in one of the graving docks. One case ended fatally, the patient having suffered from paralysis of the voluntary muscles, and absolute unconsciousness.

In 1890 there occurred what was known as the Seapoint calamity, when a mother and four children died from the effects of eating mussels. The mussels were procured from a locality to which sewage found its way.

The foregoing evidence, which could easily be supplemented, will probably be considered sufficient to illustrate the necessity for the control of mussel gathering and laying. To prevent persons from procuring mussels for market or for laying down mussels for storage or fattening near to sewer outfalls or other undesirable situations is obviously the object to be attained.

The boiling of mussels will clearly do much to reduce the chance of the conveyance of enteric fever by this means, but in the matter of ptomaine poison it is probable that the ptomaine will have been developed antecedent to the boiling process.

* "Lancet," 1880, Vol. I.

COCKLES.

The edible cockle* (*Cardium edule*) is a member of the family *Cardiadae*. It is, like the oyster, a bivalve, but by virtue of its possessing two adductor muscles in place of one, it is said to belong to the di-myarian instead of the mono-myarian divisions of the *Lamellibranchiata* (or *Pelecypoda*). The cockle ranges as far north as the Baltic, and is found in the Black Sea and in the Caspian (Woodward's *Mollusca*). In general anatomy and physiology the cockle is very similar to the oyster, and a detailed description of it is therefore uncalled for; the sexes are separate. Unlike the oyster, however, the cockle is furnished with a sickle-shaped "foot," or "tongue" as it is often called by the fishermen, by means of which it is enabled to burrow in the sand or mud in such localities as it inhabits. But even when below the surface of the sand it can still breathe, and obtain food, and get rid of its waste products, by means of an inhalent and an exhalent siphon tube formed by the prolongation of the posterior edge of the mantle.

The cockle has a wide distribution around the English and Welsh littoral. It frequents for the most part sandy shores, and it is in localities where large areas of sand are exposed at low water that the cockle industry is more particularly prosecuted. The cockle is used extensively for human food, being eaten at times, and especially during periods of famine, by the poor of most maritime districts.

Having regard to the almost ubiquitous distribution of cockles around our coast, it is impracticable to describe the localities in which they are found in anything approaching such detail as has been attempted in the case of oysters. It is obvious that since they may be collected, wherever the coast is suitable for them, and since they are undoubtedly sometimes embedded in sands near to sewer outlets, some risk may attend their consumption in an uncooked state.

There are, however, certain considerations which serve to show that contraction of water-borne diseases by the ingestion of cockles is a somewhat remote contingency. In the first place, these molluscs are, as a rule, only eaten after having been cooked, and in the second place it is seldom that extensive cockle industries are carried on in other localities than those where large stretches of sand are exposed at low tide, and such stretches are found chiefly on the actual seashore or quite at the mouths of estuaries far away from sources of sewage contamination.

Although, therefore, cockles may occasionally be collected near to sewer outfalls, and especially where such sewer outfalls discharge near to low-water mark, it is seldom that these get into the market, so that, as a general rule, cockles supplied to the English and Welsh markets from our own littoral are, when procured, free in the main from serious risk of sewage contamination.

The chief centres of the cockle industry in England and Wales are to be found on the Seal Sand at the mouth of the Tees in Northumberland; on sandy wastes at Tetney Haven, to the south of Cleethorpes; in the Wash†; on the Maplin Sands; in the estuaries of the Exe, the Teign, and the Dart, on the south coast of Devonshire; at Penclawdd, and at the mouth of the Towey River, on the coast of South Wales; on the coast of North Wales at Portmadoc, over a large area known

* The cockle is called by the Irish the *Ruocane* or *Bruvane*.

† There were 69,240 and 82,469 cwts. of cockles landed at Boston alone during the years 1894 and 1895.

as the Lavan Sands near Aber and Llanfairfechan, as also over a somewhat similar area in the estuary of the Dee; at Lytham; and, lastly, and to a large extent, in the expanse of sand exposed at low water in Morecambe Bay. In addition to cockles from these and many other home sources of supply, including cockles from Barr in the Hebrides,* which go mainly to certain large Midland towns, a considerable quantity of these shellfish is now imported into England from the Netherlands; in fact some places are almost entirely supplied from this latter source.

It is only within quite recent years that cockles have been the subject of special regulations, and those which exist at the present time are but few, and confined to certain localities. Still, there is a very decided tendency for the fisheries committees of the sea-fisheries districts to exercise control over this industry. The supervision is in the main through the agency of byelaws enacting a close season for cockles, and rendering it an offence to take cockles otherwise than by hand, or with a rake of certain dimensions, and having definite intervals (usually $\frac{3}{4}$ inch) between its teeth. It is also enacted in certain localities that where cockles have been gathered in contravention of local byelaws that they shall again be spread out thinly over as near as practicable the area from which they were taken.

The method of procuring cockles is, as is well known, simple in the extreme. At low tide on the foreshores which are exposed in certain localities the cockle gatherers, furnished in many instances with simply a bent piece of iron, or with a rake or hoe, and a net bag or basket for holding their spoil, walk out on the sands and there commence their operations. The whereabouts of the cockle is indicated by a small hole in the sand, and, where no rake or hoe is used, by a dexterous sweep of the iron the cockle is extracted from its bed, and transferred into the cockle net. It requires considerable practice to enable the work to be carried on with celerity. Women and children are very largely engaged in the industry.

In a large number of places the cockles are despatched direct to market in their shells, and this is the practice which principally obtains in the northern counties of England. In the south, however, it is a very common practice to boil the cockles and remove them from their shell before sending them to market, a proceeding which very materially diminishes the bulk of material, and, in consequence, the cost of carriage; at times the cockles are "dry salted," or perhaps pickled in vinegar. The boiling process is carried on to a large and apparently increasing extent; in fact, it is an important local industry at Boston and Lynn (cockles from the Wash), at Leigh near Southend (cockles from Maplin Sands), and at Penclawdd and Langherne on the south coast of Wales. In certain cases cockles are stored prior to market in oyster pits or pits similarly constructed, and these pits, as has already been shown are not always free from the risks of contamination.

It will probably suffice for the purposes of this report if a somewhat detailed description of two only of these places, in so far as their cockle industry is concerned, be here given; and accordingly Leigh near Southend in Essex, and Penclawdd near Swansea in Glamorganshire, are selected as examples.

* See report by Dr. Fullarton in Eighth Annual Report of the Fishery Board for Scotland.

The Leigh Cockle Trade.

The village of Leigh has within recent years assumed considerable importance as a centre for cockle gathering, boiling, and exportation. The cockles are collected by the fishermen from off the Maplin Sands, brought by boat to Leigh, and laid down for "a tide or two," on the banks of Leigh Creek. It is said that this temporary deposition of the cockles tends to clear them of the sand acquired by them on their native beds on the Maplins. After this cleansing process the cockles are scraped into a small hand net, by means of a short rake, and washed in the bed of the Leigh Creek; they are then taken to the boiling huts, of which there are some twenty or more along the foreshore immediately west of Leigh, and boiled in coppers. The boiled cockles are then riddled in a wide meshed sieve, by which process the soft parts pass through, while the shells which remain behind are deposited in heaps near the sheds. The cockles, *i.e.*, the "fish" are, after the boiling process, washed in sundry tubs of water, packed in wicker baskets and despatched by rail; the shells are sold for oyster culch, or for the construction of garden paths, &c. These shells are apparently valued highly by oyster culturists for culch purposes, and it may be observed that Mr. Frank Buckland stated before the Select Committee on Oyster Fisheries in 1876 that "Spat are especially fond of cockles, and that the great advantage of "cockle shells, as culch, is that the oysters will grow up in handsome "bunches; they can then be broken off, and they will grow into "proper size and shape, and become handsome and fit for market." At Arcachon cockle shells have been used for culch strung together upon wire, the wire being raised about three inches off the ground by means of pegs placed at intervals on the bottom.

That the cockles laid down to "clean" in the bed of Leigh Creek are liable to pollution must, I think, be admitted, since they are often placed near one or other of the Leigh sewage outfalls. Furthermore, the cockles here, prior to boiling, are rinsed in the bed of the stream, which is certainly liable to sewage pollution; in fact, one of the Leigh outfalls is near to the cockle-boiling sheds, while just below them are other sewer outfalls. On the foreshore, which is the reverse of clean here, I observed at the time of my visit evidence of sewage.

In regard to the risk of contamination incurred by the cockles of Leigh, the question seems to be whether—assuming the boiling process to destroy all germs present—the after treatment by washing is open to suspicion. One of those engaged in boiling cockles, however, observed to me that no water should be taken from the stream during flood tide, as the sewage of Leigh floated up at that time.

The water in which the cockles are washed after boiling is taken from tubs along the foreshore, and I was informed that these tubs are filled only at high water. But even if this rule is always observed in practice, it seemed to me that the water stored in the tubs must still be liable to pollution from the Leigh sewage.

The Penclawdd Cockle Fishery.

The village of Penclawdd, in Glamorganshire, has been for very many years the chief centre of the cockle industry in Wales. It is situated in what is known as the Gower, a Flemish colony, on the south of Burry Inlet, a large estuary which at low tide exposes an extensive area of sand in which the cockles are embedded. The cockles are procured at low water from near the mouth of the Inlet by scraping the sand after the manner described already. The cockles are packed in bags and transported across the sand to the village of Penclawdd. The heavy

sacks are carried by donkeys, the smaller bags by the "cockle wives" engaged in the industry, who carry them on their heads.

On arrival at the village, large quantities of the cockles are at once boiled over open grates on the seashore in a manner very similar to the method employed at Leigh in Essex. At Penclawdd the cockles are placed directly in a metal fish-kettle, in which they are subsequently boiled for a considerable time.

The boiled cockles, after having been separated from their shells by shaking in a sieve, are washed in fresh-water streams hard by, packed in baskets or linen bags, and despatched to market. In many instances the "cockle wives" take the shell-fish into neighbouring towns, such as Swansea, Llanelly, &c., in small tubs which they carry on their heads, and sell them about the streets; in other cases the "cockle wives" have an agent or agents, also usually women, to act as sellers in certain large towns. I am told that on Saturday morning as many as 100, or more, "cockle wives" may be seen leaving Penclawdd station with cockles for the different towns. The cockles I observed being procured at the time of my visit were somewhat small, and I am informed that the cockle industry at Penclawdd has fallen off of late years, larger cockles being procurable from the Wash and other places. There is no doubt, however, that the Penclawdd cockles possess an excellent flavour and are much appreciated by lovers of shell-fish. In former years there was a cockle merchant at Penclawdd who did most of the trade, sending away large quantities of cockles to different parts of the country; but at the present time each "cockler" or cockling family apparently carries on business independently.

I am indebted to the station master at Penclawdd for kindly furnishing me with the subjoined figures of the fish (chiefly cockles) conveyed inland from that station for the 17 years ended December 31st, 1895.*

From an inspection of the locality it does not appear that the cockles collected hereabouts are liable to sewage pollution, but I experienced a difficulty in obtaining precise information as to all the places in which the cockles were washed after boiling. In those instances in which I observed the process, the water used appeared free from pollution, and the washing of the cockles was of a most thorough nature.

Speaking of the English cockle industry as a whole, the places from which they are derived are rarely open to much risk of sewage pollution; and if the cockles were invariably boiled before being eaten such exceptional risk as does exist is probably but a small one. At the same time the risks which do exist are, as a rule, quite obvious and should be remedied.

* RETURN of FISH (chiefly Cockles) conveyed Inland for 17 years ending December 31st, 1895.

Year.	Tons.	Cwts.	Year.	Tons.	Cwts.
1879 - - -	228	5	1888 - - -	8	7
1880 - - -	138	14	1889 - - -	51	5
1881 - - -	202	19	1890 - - -	12	10
1882 - - -	244	17	1891 - - -	3	17
1883 - - -	292	10	1892 - - -	7	17
1884 - - -	150	15	1893 - - -	12	7
1885 - - -	64	12	1894 - - -	11	6
1886 - - -	48	16	1895 - - -	4	9
1887 - - -	30	10			

PERIWINKLES.

The common periwinkle* (*Littorina littorea*) is a univalve mollusc belonging to the class *Gasteropoda*, and to the family of *Littorinidæ*; and unlike the molluscs previously considered it is furnished with a head and tongue. It has a wide geographical distribution, and inhabits the lowest zones of seaweed between the tidal limits. Over this mollusc there is practically no control at present, save that in certain fishery districts it is not allowed to be taken during what is regarded as the spawning period. For instance, in the Sussex district the close time is between April 1st and October 31st, in the "Southern" district between May 1st and August 31st, and in the Stour district the limitations extend from May 15th to August 15th.

Methods of gathering periwinkles are familiar to all frequenters of the sea shore, and it is unnecessary to discuss them here.

Obviously these shell-fish may be, and doubtless sometimes are, procured from undesirable situations, but the fact that they are almost invariably cooked prior to consumption does much to remove them from the suspicion that attaches to uncooked oysters as vehicles by which enteric fever may be conveyed. For the most part periwinkles are collected for despatch in bags direct to market from the sea shores, but in some instances periwinkles and periwinkle brood obtained both from our own shores, and also from abroad, are scattered over the foreshores. It seems unnecessary to devote more space to this article of food, as very similar observations apply to periwinkles as to mussels, and any restrictions imposed upon the one are equally applicable to the other.

* "In Anglo-Saxon the periwinkle is called 'Sea Snagl' or 'Sea Snail'; in Ireland, the 'Horse Winkle,' and 'Shellimidy Forragy,' and at Belfast, 'Whelks'; in Cornwall 'Gwean' or 'Guihan'; and in the North 'Corvins'; and the French give it the name of 'Sabot' or 'Wooden Shoe,' as well as 'Vignot' or 'Vignette,' and 'Bigorneau.'"—"Edible British Molluscs," Lovell.

“GREEN-BEARDED” OR “GREEN-FINNED” OYSTERS.

A short reference may not inaptly be made here to what are known as “green-bearded” or “green-finned” oysters, more especially since allusion has been made to the subject in the body of this report (see pages 33 and 56). For much of the information here given I am indebted to an article by Professor Ray Lankester, in vol. XXVI. of the “Quarterly Journal of the Microscopical Society.” I may add that I have visited localities, both at home and abroad, in which these “green-finned” oysters are found.

In some of the estuaries of Essex, oysters, during certain years and at certain seasons of these years, are green as to their *branchiæ* and *labial palps*. Such greenness prevents, even at the present day, the sale of these oysters for food in England; and oysters so coloured are either exported to the Continent or withheld from sale for the time being.

It was formerly supposed, and, indeed, the belief is still very general, that the greenness of oysters was due in some way or other to the presence in them of copper, derived from sea water in relation with copper mines or in contact with ships sheathed in copper; and this view seems to have been held indiscriminately in respect to all green oysters, whatever was the locality from which they were procured, and whatever the tint or distribution of the colouration. Persons holding this belief appear to have lost sight of the fact that in many instances where this greening was to be observed in oysters there were no copper mines near to them, nor was the presence of copper-bottomed vessels at all likely.

On the other hand, oysters presenting a greenness similar in distribution and much more intense than that presented at times by the oysters on parts of the Essex foreshores, have for ages been appreciated in France more highly than what may be termed normal coloured oysters; so much so, indeed, that the “*huîtres vertes*” or “*huîtres de Marennes*,” as they are called in France, command a higher price in the Paris market* than the “*huîtres blanches*,” while infinite trouble is taken in the oyster claires of Marennes, in the Bay of Biscay, to convert “*huîtres blanches*” into “*huîtres vertes*.” Between the green oysters of Essex and those of Marennes the difference is one of degree only, as has been pointed out by Professor Ray Lankester in the article above referred to. Such greenness is in no way dependent upon the presence of copper; and in reference to the green oysters of Essex it is of interest to note that as far back as 1863 chemical analysis of samples of them was made by the late Dr. Letheby. This analysis together with a letter from the late Mr. Frank Buckland, both of which were given to me by Mr. Frederick Wiseman, of Paglesham, Essex, are here reproduced, since they are of some historical interest in relation to the question of green oysters.

“*Green-Bearded Oysters. River Roach, Essex.*”

Fredk. Wiseman, Esq.
Sir,

41, Finsbury Square
Dec. 2nd, 1863.

In accordance with your request, I have made a very careful examination of the Green Finn'd Oysters from the River Roach, or

* In Paris, in 1895, I found that the green oysters were being sold for 1*fr.* 50 c. the white for 1*fr.*, the dozen.

Crouch, and find that the green tint, which is present in the gills only of the oyster, is due entirely to a natural pigment which does not contain a trace of copper or other deleterious matter. The oysters are therefore perfectly nutritious and wholesome.

(Signed) HENRY LETHEBY, M.A., &c.

Professor of Chemistry in the College of the London Hospital,
Medical Officer of Health, and Food Analyst for the City of
London.

"The late Frank Buckland, Esq. (Her Majesty's Inspector of Fisheries), speaking of these oysters in "Land and Water," said:—

"Essex Green-Bearded Native Oysters.—I am glad to inform the public that the green-bearded oysters native to the River Roach (not far from Southend, Essex), are about to be introduced into the London market. For over a hundred years this kind of British oyster has been shipped *viâ* Ostend to the Paris and continental markets, where, under the name of 'Les huitres verts d'Ostende,' they have been and are considered a great delicacy. The reason why oyster-eaters in England have not hitherto availed themselves of these home-bred oysters is that their beards (that is, breathing gills) are in the winter months more or less tinged with a green pigment. This peculiar green is imparted to them by the sporules of the sea-weed 'crow-silk,' which grows abundantly in the Roach river. Dr. Letheby's analysis has pronounced this pigment to be purely vegetable, without the slightest trace of copper or other mineral. I consider that this vegetable pigment imparts a peculiar taste and agreeable flavour to the meat of these plump little oysters. For many years I have been trying to persuade the Messrs. J. and F. Wiseman, oyster merchants, Paglesham, Rochford, Essex, to send their natives to the home markets. The present scarcity of oysters has now induced them to supply the English rather than the French markets. The shells are thin and porcelain-like, and the proportion of meat to shell in my catalogue of oysters is one-fifth.—FRANK BUCKLAND."

That the green oysters of Essex are quite as palatable as the green oysters of Marennes is a fact within the personal experience of the writer.

The precise nature of the greenness of the French oysters has excited much interest at different times during very many years. As long ago as 1820, M. Benjamin Gaillon* demonstrated by the aid of his microscope that the greenness of the French oyster was due to a particular species of *Diatom*, which he proposed to call *Vibrio ostrearius*, and he controverted the view that the greenness in question was due to the chlorophyll of certain green *algæ* upon which the oyster was supposed to feed. Gaillon also made the very important observation that other molluscs placed in the water containing the *vibrio* absorbed some of the colour, and that the *vibrio* and the greening of the oyster come and go together; that, when there is no greening of the water in which the oysters are contained, the oysters remain free from the green colouration.

In the year 1824, M. Gaillon suggested, in the "Memoirs of the Linnean Society of Calvados," that the branchiæ of the oyster select and deposit the colouring matter in a similar manner to that in which the osseous tissue of pigs, fed upon madder, select and deposit the red colouring matter of that plant.

In 1835, Bizio, of Venice, discovered that the tissue of the oyster contained a minute trace of copper, and he suggested in 1845 that the green colouration of oysters was due in some way to the presence of

* "Des Huitres Vertes et Des Causes de Cette Coloration" par M. Benj. Gaillon (Journal de Physique, Tome xci., Sept. 1820).

copper contained in the organic substance of the mollusc. Bizio's discovery of copper in oysters was a notable one; and although there seems to have been but little doubt but that the copper which he detected was due to the presence of hæmocyacin, which is a normal constituent of many molluscs, it is important that the discovery should be borne in mind in reference to some observations which will shortly be made as to the green oysters of Falmouth and Truro.

M. Valenciennes,* in the year 1841, showed that the greenness of oysters, in addition to its appearing on the gills and labial palps, was to be observed in the liver, but he was unable to detect its presence in the muscles, nerves, heart, reproductive organs, or blood. Valenciennes also, in company with Dumas, chemically examined green coloured sections of oysters, and demonstrated the absence from them of copper; they regarded the colouration as being due to a hitherto undiscovered organic compound. Finally, Valenciennes suggested that the colouring matter was manufactured in the intestine and liver of the oyster, and that after absorption it was deposited in the gills.

Puségur and Decaisne† showed experimentally in or about 1877 that white oysters placed for a short period in water containing the *Navicula ostrearia*‡ rapidly assumed a green tint, and that when these oysters were removed from that environment and placed in sea water from which the *Navicula* was absent, they shortly lose their green colouration. Puségur also showed that oysters deposited in a bath of sulphate of copper are not thereby coloured, and that the oyster under these conditions soon dies. He examined the intestinal tracts of green oyster's, and showed that the stomach, intestine, and excrement were full of the "tests" of the *Navicula*, the soft part of the diatom having been absorbed.

Ryder, in a paper entitled "Notes on the Breeding, Food, and Green Colour of the Oyster," contained in the "Bulletin of the United States Fish Commission," vol. i., 1881, states that certain "Anglo-Portuguese" oysters obtained from England had the gills, liver, heart, and mantle deeply tinged in certain parts with greenness, and that some of these oysters were examined by Professor H. C. Lewis, of the Academy of Natural Sciences of Philadelphia, with a view to the detection of copper, but that the results were negative. Ryder adds, too, that, in 1879, Professor Endlich, of the Smithsonian Institute, had already examined some green oysters or copper with a similar result. Ryder, in the article above referred to, states that in some very "poor" Falmouth oysters, very much affected with green colouration, the gills, heart, and mantle were most notably coloured, and that in one instance he discovered a large cyst in the mantle crowded with green-coloured cells. He found the hearts of the affected oysters much thicker than those unaffected, and states that "the muscular trabeculæ which interlaced on the inside were found to have "entrapped and held in their meshes vast numbers of the loose green "cells"; and that in some cases, "the entire ventricle was so loaded

* "Sur les causes de la coloration en vert de certaines Huitres"; par M. A. Valenciennes, Comptes Rendus de l'Académie des Sciences, 1841.

† "On the Cause of the Greening of Oysters," by M. Puségur and by J. A. Ryder, see Part x. of the United States Fish Commissioners' Report for 1882, published in 1884; also "Notice sur la Cause du Verdissement des Huitres," par M. Puségur, Sous-commissaire de la Marine, Chevalier de la Legion d'Honneur.—Extr. de la Rev. Maritime et Coloniale.

‡ This diatom is now known as *Navicula fusiformis* var. *ostrearia*. See Report upon the Methods of Oyster and Mussel Culture on the West Coast of France, by Prof. W. A. Herdman, D.Sc., F.R.S.

“with these as to render it quite opaque when viewed with transmitted light.” These cells Ryder regarded as blood corpuscles which had taken up a green colouration, and he apparently is of opinion that the greenness of the heart and the mantle is due to an accumulation of these green cells therein. Green oysters are, Ryder thinks, quite as common on the coasts of the United States as in Europe, and he considers the cause in all cases identical; he has, however, heard of only one locality in which the green-finned oysters are appreciated in America, *i.e.*, at Norfolk.* It should also be recorded here that M. Bornet in 1877 first noted that the colour of the *Navicula* is blue and not green.

In 1885, Professor Ray Lankester published in the journal already referred to some valuable additions to our knowledge as to the green colouration of oysters. He demonstrated, as, apparently, Puségur and Decaisne had done, the “envelopes” of the *Navicula* in the stomach of the Marennes green oyster; he showed that a blue pigment, which he termed “*Marennin*” occurs in the *Navicula*, and that this pigment is sometimes uniformly diffused throughout the cell protoplasm, and in others confined to the ends of the elongated cell body. Professor Lankester also furnished in his paper some excellent coloured drawings of the *Navicula ostrearia*, as well as an exceptionally faithful picture of a green oyster of Marennes. Professor Lankester was unsuccessful in all his attempts to dissolve out the green colouring matter of the green oysters gills by means of chemical reagents, and he showed that spectroscopically the pigment of the *Navicula ostrearia* and that of Marennes oysters present many features in common.

On turning his attention to the microscopical appearance of the green oyster’s gills and labial palps, and to the mode of distribution of the pigment, Professor Lankester found that the green colouring matter is localised on the surface of the gills and labial palps in “certain peculiar cells of the superficial epithelium.” These cells he regards as secretion cells, and the pigment, he finds, occurs in granules that they contain. These cells, be it observed, are not peculiar to the green oyster, but they occur also—minus the green colouration—in the gills of the colourless oyster. Where these cells are present in the green oyster, there is the greenness found, and it is the deposition of this blue pigment of Marennin in the yellowish brown gills of the oyster which gives rise, Professor Lankester considers, to the green appearance observed. We are not, he observes, in a position to state what slight chemical modification the marennin undergoes in order that it may be rendered diffusible.†

It may therefore be concluded that the greenness of the oysters of Marennes and of Essex is in no way due to the presence of copper, although, as Bizio first discovered in 1835, the tissues of all oyster contain a small quantity of that metal.‡

In reference to these green oysters of Marennes, it may be well, before proceeding to another point, to give a brief account of the method adopted for “greening” the oysters in question. In this connexion processes of oyster culture adopted on the west coast of France are also of interest.

The oysters which are to undergo this “greening” process are, as a rule, procured from Arcachon, which is the most important oyster-

* “Bulletin of United States Fish Commission,” vol. iii., 1883.

† See also investigation of Chatin in *Comptes Rendus de l’Académie des Sciences*. Tome 116.

‡ See paper read by Dr. Kohn before the British Association at Liverpool in 1896.

NOTE.—See also “Nature,” May 9th and October 31st, 1895.

breeding centre in France. At this place, which is situated in the Department of Gironde, a little south of Bordeaux, there is an extensive inland sea known as the "Bassin d'Arcachon," which is connected with the Bay of Biscay by a narrow strait passing between Capé Ferret and Pointe du Sud. At low tide extensive areas are exposed, which are known locally as "crassats," and it is upon certain of these that oyster culture is carried on. These areas are divided into numerous separate layings or "parcs," which are partitioned off from one another by means of low clay walls, supported on either side by heather branches. This arrangement enables a few inches of water to be retained over the oysters even at quite low tide, although by means of sluices the "parcs" can be entirely emptied at will. These "parcs" are approached by alley ways or canals, which run in a certain direction over the "crassats," and thus the parcs can be approached by boat without inconvenience. The sides of the canals are planted with saplings, which serve in the main to indicate the whereabouts of the channels before the parc walls are exposed by the falling tide, and are also said to scare away certain of the oyster's enemies.

In sundry spots over the "bassin" are areas ("bancs réservés"), which are held by the State for the purpose of furnishing larval oysters for the supply of the private "parcs." On some of these reserves the gathering of oysters is never allowed, while in others it is only permitted on two days in every four years; but the interval appears, as far as I was able to ascertain while at Arcachon, to be somewhat variable.*

The larval oysters are "collected" on tiles, covered with a specially prepared cement, which are contained in wooden crates (*gabarets*) or held together by galvanized wire (*bouquets*). These "collectors," are placed in position in the parcs about the end of June or beginning of July, efforts being made to arrange them as near as possible to the spatting period. If the tiles become covered with slime the larval oysters will not adhere thereto, and it may often be observed that the convex surface (which is always placed uppermost) of the topmost tile is devoid of spat, while the lower concave surface, which has remained free from slime, is thickly covered. The oyster spat is allowed to remain on the tiles until about October,† when the tiles are gathered, placed in barges, and taken to the huts situate on the shore, or on the Ile des Oiseaux in the middle of the "bassin." Here the operation of "*détroquage*," or the separation of the oysters from the tile, takes place. Formerly, it was a practice to break the tiles themselves, but the discovery of the cementing process has superseded this practice; young oysters are now removed by peeling off the cement by the aid of a kind of chisel. The separated oysters are then taken to parcs, and placed in what are known as "ambulances" which are really trays some 6 inches deep, 6 feet long, and 4 feet broad, covered above and below with wire netting. By this arrangement the young and delicate oysters are raised above the mud at the same time that they are kept secure from the enemies that might attack them were they unprotected. The oysters in these ambulances are frequently culled over and the larger removed to other ambulances. On being taken finally from the ambulances the oysters are placed on the bottom of the parcs there to grow until marketable, or until they are sent elsewhere to "fatten," or to be "greened."

* On the State grounds on May 24th, 1895, dredging by 172 boats yielded 423,800 oysters, representing a value of 2,789 francs, and on the following day the crews of 486 boats obtained by hand 1,462,900 oysters, valued at 8,698 francs.

† In some places the spat is allowed to remain on the tile over Christmas, but it is thought by certain authorities that this procedure involves unnecessary risk of loss.

It is in the "claires" of Marennes, which place is situated in Charente Inférieure, a little north of the mouth of the Gironde, that the greening process is very largely carried on. Here, in the salt marshes—which are a noticeable feature in the landscape hereabouts—are numerous ponds or "claires." These "claires" are fed with water by means of canals, and their position is such that their water can only be changed at spring tides. Their sides are covered to the water's edge with marsh herbage and they are furnished with sluices. In the spring of the year the "claires" are emptied, and the bottoms broken up and allowed to be thoroughly aerated. The bottoms are so arranged that they slope down yards from the middle line to the sides, an arrangement which allows the muddy deposit to collect in the side channels and to be removed. After being dug over the soil is left exposed to the sun until about the beginning of August, when a small amount of water, just sufficient to cover the surface, is admitted. A little later, water to the depth of about 1 foot is let in, and it is found that the contents of the ponds rapidly assume a bluish-green appearance—the condition which is instrumental in bringing about the colouration of the oysters.

In some instances the green oysters, before being despatched to market, are submitted to what is known as *dégorgement*, i.e., they are placed in specially prepared ponds or pits with cement bottoms and sides of concrete or brick, for the purpose of allowing the oysters to get rid of any mud which they may have acquired in the "claires." The oysters when required are packed up for market in baskets with bracken, and in this condition they will travel safely for very long distances.*

It is difficult to peruse the literature appertaining to the question of green oysters, and to visit localities where oysters from time to time exhibit a green colouration, without arriving at the conclusion that oysters are subject to more than one kind of greenness. At the outset of this inquiry I was struck with a peculiar greenness which certain American and Portuguese oysters, relaid in English estuaries, presented, and I was unable to reconcile the appearance they presented with the descriptions given of the green oysters of Marennes, or with the appearance of the green oysters that I had observed in Essex. When too, later on, I visited the "claires" of Marennes, and examined the famous "huîtres vertes" of that locality, I was still further puzzled, and, finally, on visiting Falmouth and Truro and examining the green oysters of that district. I was forced to the conclusion that the greenness of the Marennes and Essex oysters differed in many particulars from the greenness seen occasionally both in American and Portuguese oysters, and from that common in *O. edulis* in certain areas of the Falmouth and Truro waters. At this stage of my observations I was much interested to find that Professor Herdman, F.R.S., in his report for 1895 on the Lancashire Sea-Fisheries Laboratory at University College, Liverpool, states that during some of his experiments a green tinge of more or less intensity made its appearance on the *mantle* and other parts of the body of certain oysters. Such greenness, he observes, is very different to that presented by the celebrated French oyster. It was noted by him in some American oysters freshly imported, and appeared also at times in oysters relaid on the Lancashire coast. The greenness, Professor

* These baskets may be seen outside the oyster shops of Paris with heavy weights placed upon the oysters they contain, so as to prevent the molluscs opening their valves and thus losing their "liquor."

Herdman reports, was familiar to the local oyster importers and merchants, who regarded it as due to the presence of copper.

Professor Herdman and Mr. Andrew Scott tested these oysters for copper, but found there was very little present in the green parts; no more, in fact, than was present in the same parts of colourless oysters. These two observers also made the experiment of keeping oysters in old copper vessels, and in vessels of sea water containing sulphate and other salts of copper in solution, in amounts varying from 0.02 to 0.2 per cent. of copper in 10 litres of water. None of the oysters placed therein acquired green colouration, save such as was produced by copper superficially deposited on their shells. After death of the oyster, however, some staining of its body became apparent. The pale greenness which Professor Herdman observed in the American oysters he regards as "an inflammatory condition or leucocytosis," in which enormous numbers of wandering leucocytes filled with large green granules come out on the surface of the body, especially of the mantle.

As far as can be gathered from the published accounts relative to green oysters, it appears that all such oysters, whatever their origin, have (whatever the view of local fishermen and others) been regarded by writers on the subject as equally palatable with those normally coloured. As has been remarked above the green oysters of Essex and Marennes are certainly in no way inferior in gustatory qualities to the "white;" but this cannot in my experience be said of the green oysters of Falmouth and Truro, and it is to these oysters that I shall confine my concluding remarks.

It was reported to me locally that such oysters were quite unfit for immediate consumption, and that they left behind in the mouth a distinct metallic taste, similar, it was said, to that which might be expected from "sucking a penny." Having regard, however, to the investigations and the papers to which I have referred I was highly sceptical on this point. The statements, though, were so positive, and made by those who would be unlikely to be biassed by a rumour, that I determined to taste certain specimens for my own satisfaction. I, therefore, with the fishery bailiff of the Truro Corporation, visited one of the areas over which oysters are liable to greenness and swallowed about a dozen of the greenest oysters that could be found. The reported metallic taste was at once appreciated by me, and it was only with the greatest difficulty that I could complete the task I had set myself; the rough metallic taste persisted indeed for some three hours after I had swallowed the oysters. Beyond this I experienced no ill effects.

With the view of throwing if possible some light upon the cause of this greenness and metallic taste, or of at least supplying negative evidence which might be of value, some 50 oysters were procured for me by Mr. Rupert Vallentin, and despatched to Professor Thorpe, F.R.S., Director of the Government Laboratory, Somerset House, who had undertaken to examine them for copper. After submitting the oysters to analysis, Prof. Thorpe reported as follows:—

"The Cornish oysters contain notable quantities of copper. On drying and incinerating the oysters no difficulty was met with in detecting the metallic oxide in the ash. To determine the amount, a dozen oysters were dried and incinerated in a platinum basin in a muffler. The cupric oxide obtained was 0.26 grains. A second experiment was made on 24 oysters; the amount of cupric oxide present was 0.48 grains. It would appear, therefore, that the average amount of copper oxide per oyster is about 0.02 grains, although, to judge

from the very unequal development of the green colour, individual oysters may contain much larger quantities."

Professor Thorpe also informed me that certain oysters selected for their marked greenness yielded a much larger amount of copper per oyster than that referred to above.

These results were so interesting that it was resolved to repeat the examination with another batch of oysters taken from the same locality, and to check the results by the examination of certain oysters which had been in all probability once green, but which, having been laid down in one of the creeks abutting upon the Carrick Roads, had lost their greenness, as they are wont to do under these conditions, and become marketable (see account of Falmouth and Truro oyster fisheries, p. 55). By help of Captain Anderson, of Whitstable, some oysters which had never been green were also procured and forwarded for analysis in order further to check the results obtained with the green oysters. It was in addition resolved to obtain some specimens of water taken from over the spot whence the green Falmouth oysters came, as also from a creek there which was locally stated to possibly bring down copper. A specimen of water was also procured from a creek in which green oysters rapidly become "white."

Reporting upon the oysters above referred to, Professor Thorpe states :—

"Operating in each case upon 24 oysters, and making duplicate experiments, we found that the Falmouth oysters, when green, contained on an average 0·023 grains of copper per oyster. After relaying, and when oysters had become 'white,' the amount of copper was on an average 0·0060 grains per oyster."

Professor Thorpe reports further, in reference to the oysters forwarded by Captain Anderson, that they contained almost the same amount of copper as the "white" Cornish oysters, viz., 0·0062 grains per oyster.

From these observations it appears that it would be necessary for a person to consume some four dozen green Falmouth oysters in order to procure one grain of copper, while to obtain the same amount of copper from "white" oysters the consumption of some 14 dozen would be necessary. It would seem, too, from these results, that the amount of copper contained normally by the oyster, and to which Bizio first drew attention many years ago, is about 0·0062 grains per oyster, though doubtless the amount varies considerably in different oysters.

The specimens of water, to which reference has already been made, were examined in the absence of Dr. Frankland by his assistant, Mr. Wm. Burgess. He reports that the sample taken at low water, off Devoran, a village on Restrongnet Creek, which pours its water over the green oysters, contained 0·22 parts of copper in solution, and 0·03 parts in suspension, in 100,000 parts of water. The other water samples, one of which was taken from over the area where oysters are frequently green, contained no appreciable amount of copper salts.*

It may be observed here, in reference to the question as to whether the copper found in the green oysters was due to the water contained in, or around, the tissues of the oyster, that "white" oysters, procured side by side with the green, contained only the same amount of copper as oysters which had never been green, and that not only is the amount of copper in direct proportion to their greenness, but the metallic taste,

* It would seem, however, not unlikely that, after periods of heavy rain, copper might be brought down by the waters of Restrongnet Creek in larger quantities than this analysis would seem to indicate.

peculiar to the Falmouth green oysters, is also directly associated with the greenness.

In addition to the above, and at Professor Thorpe's suggestion, a sample of mud was procured by the co-operation of Mr. Rupert Vallentin from the locality from which the green oysters were taken, and another from a point in Falmouth Harbour where oysters do not evince a green colouration; the first mentioned specimen yielded 0·148 per cent. of copper, the second 0·032 per cent.

The greenness of the Falmouth and Truro oysters differs, as has been remarked, from that of the Marennes and the Essex oysters in certain particulars, and these it may be well to describe in some detail.

In the first place the colour is different, that of the Marennes oysters being a distinctly bluish-green, that of the Falmouth oysters a pronounced "coppery" green. In the next, the distribution of the colouration is different; the greenness of the Marennes oysters being confined almost exclusively to the branchiæ and labial palps, that of the Falmouth oyster being less circumscribed. In Falmouth oysters the colouration affects sometimes the mantle or parts of the mantle, sometimes parts of the branchiæ or of the "body," while now and again the greenness may be more or less generally diffused over the whole oyster. The greening of the Marennes and Essex oysters is observed only in certain seasons of the year; that of the Falmouth and Truro oysters persists, it appears, all the year round. Again, the former oysters are much appreciated on the Continent, whereas the Falmouth green oysters would certainly never be demanded on a second occasion. The Marennes and Essex oysters contain but a small amount of copper, the Falmouth oysters contain this metal in considerable quantity, and apparently in amount directly proportionate to their greenness.

In view of these interesting results it is worth noting that the "Field" of November 15th, 1862, contains the following extract, apparently taken from Penwarne's "Common-Place Book," and which relates to an analysis of Falmouth green oysters made as far back as the end of the last century.

"Dr. Paris in his excellent treatise on diet, says that *copper never gives* to oysters a green tinge, and that they contain none. This I am enabled to confute, and indeed I wonder that the doctor's acuteness could have been so far deceived, especially having resided so long in Cornwall. In certain parts of Falmouth Harbour they are so impregnated with copper as to be as green as if dyed with verdigris. This led me to attempt the extraction of it. I procured about a hundred or more of them, put them into a large crucible, and reduced them to ashes, and continued to increase the heat until the copper was melted; but from the quantity of ashes and an insufficiency of flux I did not obtain the whole of the metal—perhaps not one quarter; yet the produce was a bright bead of *pure copper* of about this size ○. Who after this will say that oysters never contain copper? The copper might have accumulated from the wash of the stamping mills, but I rather suspect the oysters lay on a lode, for some of them were strongly impregnated with *iron*, as if they had lain on the *gcssan* which always attends a copper lode. Besides, there was the appearance of a large lode in the cliff opposite the place, in St. Just's Pool."

From the "British Medical Journal" of March 25th, 1863, I abstract the following:—

"M. Cuzent has read a note to the Academy of Sciences entitled 'Poisoning by Oysters taken on a Bank near a Copper Mine and Demonstration of the Presence of Copper in these Molluscs.' The oysters

in question came, he says, from England, and were taken near Falmouth, in the neighbourhood of a copper mine. These animals have occasioned, he mentions, some symptoms of poisoning."

In the following week it was stated in the same journal that the oysters above referred to were imported from Falmouth to Marennes, and were laid down in the *claires* to lose their "salted copper taste" and to acquire the green of the Marennes oysters, but the oysters under consideration do not appear to have been deposited for a time sufficient to allow of their losing the green colour they had acquired at Falmouth.

The "Annals of Natural History," vol. xviii., 1866, contains an article on green oysters by Mr. Arthur W. G. O'Shaughnessy, of the British Museum, and in it the author points out that Cuzent found that no less than an average of "23 centigrammes (about $3\frac{1}{2}$ grains) of salt of copper was yielded by a dozen of these oysters." The water from which these oysters were procured at Falmouth was found, it is stated, strongly impregnated with salts of copper.

Professor Ray Lankester is inclined to regard the statement that the oysters in question were Falmouth oysters as an ingenious excuse set up by the fishmonger, who, he infers, had fraudulently stained "white" oysters with copper to supply a demand for green oysters which he was unable to meet; and Professor Lankester also draws attention to an instance which occurred in 1713, and which is cited by Dr Johnston in his "Introduction to Conchology," as also in Mr. O'Shaughnessy's article already referred to, of a fishmonger at the Hague who stained oysters green with copper. Certainly the very large amount of copper said to have been found by Cuzent in the reputed Falmouth oysters would seem to point to some attempts at staining them; but on the other hand, the efforts made to stain oysters with copper by Puségur and Decaisne, as also more recently by Herdman and Scott, would seem to raise questions whether such a practice is feasible, at any rate with the salt of copper and by the methods that they used. Taking, too, the Cornish green oysters as an index, it is difficult to believe that oysters impregnated with copper would be likely to pass muster either in appearance or taste as Marennes oysters.

However this may be, the facts above brought forward as to the presence and excess of copper in the Falmouth green-oysters, and as to the direct relation which the amount of copper appears to bear to the greenness of these oysters, would seem to be worthy of being put on record as a not unimportant contribution to this very interesting subject. There is clearly much yet to be learnt in reference to the greenness of these Falmouth and Truro oysters.

APPENDIX No. 2.

REPORT by DR. KLEIN ON HIS BACTERIOLOGICAL RESEARCHES.

The work that I have carried out in connexion with Dr. Bulstrode's Oyster Inquiry has comprised investigation under the following heads:—

1. Identification of the microbes on and within oysters derived from a number of different localities.
2. The ability—
 - (a.) Of oysters, under experimental conditions in tanks wherein culture of the typhoid bacillus is suspended in sea water, to admit to their interior the microbe of enteric fever.
 - (b.) Of the typhoid bacillus to subsist in sea water under certain conditions of experiment.
3. The ability—
 - (a.) Of oysters, under experimental conditions in tanks wherein culture of Koch's vibrio is suspended in sea-water, to admit to their interior the cholera micro-organism.
 - (b.) Of the cholera vibrio to subsist in sea water under certain conditions of experiment.

1.—IDENTIFICATION OF MICROBES ON AND WITHIN OYSTERS.

Oysters which were in a fresh and living state, *i.e.*, having their valves firmly closed, were alone selected for examination. Each oyster was carefully washed and brushed in a small quantity of sterile water, with a view to collecting therein any microbes adhering to its shells. Next, the oyster, after a further cleansing under a water tap and drying with a clean cloth, was opened with a sterile knife and its body mashed up with the liquor contained in its shell. Both classes of material, that obtained from the outside of the oyster and that (including water) which had been contained within its shells, were now ready for detailed examination.

At an early stage of this inquiry, as well as in some previous investigations of similar sort, I had ascertained that the oyster does not under normal conditions contain—either within its body or in the liquor enclosed by its shells—any microbe that can grow in phenolated gelatine or in phenol broth. Thus I had found that by far the most abundant micro-organism in the ordinary oyster is a minute mobile bacillus capable of liquefying gelatine very rapidly, but not (like *proteus vulgaris*) growing in broth at 37° C. Occasionally only, a spore forming mobile bacillus is also obtained, which corresponds culturally to *bacillus mesentericus*. A non-liquefying bacillus is too, as a rule, present, which differs conspicuously from *bacillus coli* in the circumstance that it will not grow in broth at 37° C. The number of microbes of the above sorts present in the liquor and in the body of the oyster varies greatly in different samples; of oysters from the same batch, some afford few, some innumerable colonies, to the gelatine plate culture test.

Having satisfied myself in the above sense that bacteria of excremental origin are not in the ordinary course apt to be contained within oysters, I set myself to ascertain whether microbes of this class, *e.g.*, *bacillus coli* and the typhoid bacillus, were or were not discoverable in samples of the mollusc from time to time submitted to me by Dr. Bulstrode from one and another locality where oyster layings, fattening beds, or storage pits were under more or less suspicion of sewage contamination. In my view, the presence on or within an oyster of *bacillus coli* is strongly suggestive, and the presence of the typhoid

bacillus practically a demonstration, of fouling of the particular sample with material of excremental origin.

By way of detecting these microbes in material on or from within oysters, as the case might be, portions of the sterile water used for cleansing the outside of the shells and of the emulsion of oyster-body and oyster-liquor respectively were transferred to phenol broth and to phenolated gelatine plates, which were incubated in due course, the latter at 20° and the former at 37° C. If, at the end of 24 hours, indications of microbial growth appeared in the broth, further phenolated gelatine plates were inoculated therewith. These in turn, *i.e.*, as soon as colonies appeared on them, were carefully examined under a magnifying glass, and such colonies as in any way resembled bacillus coli or the typhoid bacillus were subjected to further test—as, for instance, microscopically, in fresh “hanging drop” and in stained cover-glass specimens, and culturally in the several media wherein these microbes best exhibit their distinctive features.

I have in a former report (Report of the Medical Officer of the Local Government Board for 1892–93, pages 348, 349, and 350) described the morphological and cultural characters of the typical bacillus coli obtained from human faecal matter, and of the typical typhoid bacillus obtained from the spleen of cases of typhoid fever. These I here repeat, adding certain other distinguishing features whereby the two microbes may be differentiated.

Bacillus coli—

- (a.) Is an oval or short cylindrical rod, rounded at the ends: in a recent culture few individuals are long cylinders or filaments.
- (b.) Examined in broth culture as a “hanging drop,” some examples show active mobility, but the majority do not.
- (c.) When these bacilli, taken from an agar culture incubated 16–24 hours, at 37° C., are stained after Van Ermengem’s method, they show two, three, to eight flagella, more or less wavy, but not markedly spiral.*
- (d.) The colonies of bacillus coli on ordinary and on phenolated gelatine, appear, after 24 hours, as greyish translucent dry angular patches, thicker in the centre filmy in the margin; during the next day or two they increase much in size, remain flat, thicker in the centre thinner and filmy at the margin, and appear whitish in reflected, brownish in transmitted, light; the gelatine is not liquefied.†
- (e.) In gelatine streak culture the growth extends rapidly, forming a filmy expansion along the line of inoculation which rapidly spreads out in breadth. The growth, which presents a flat and dry appearance, is thicker in the middle, filmy, crenate, and irregular in the peripheral parts; in transmitted light it is brownish in the middle and translucent in the marginal parts.
- (f.) In gelatine shake culture numerous gas bubbles form in connexion with the colonies, giving to the culture a characteristic appearance.
- (g.) Milk incubated at 37° C., is rapidly curdled by the bacillus, usually in 24–36 hours.
- (h.) Broth is made uniformly turbid by it at 37° C. in 24 hours; after 3–5 days there is a voluminous flocculent deposit, and on the

* PLATE XII., figs. 28 and 29, page 147.

† PLATE I., fig. 1, page 136.

surface indication of a pellicle. On adding to such a culture nitric acid a distinct pink coloration—nitrosoindol—is produced.

- (i.) On steamed potato a sticky yellow brown growth is noticeable after 2-3 days' incubation at 37° C.
- (j.) In 25 per cent. nutrient gelatine incubated at 37° C. there is, after 24-48 hours, a thick pellicle formed, the (liquefied) gelatine remaining clear.
- (k.) This microbe is a strong producer of acid (Petruschki); so that when growing in neutral litmus whey it rapidly turns the litmus red, and when growing at 37° C., in nutritive fluid containing alkali albumin, it solidifies the fluid owing to coagulation of the albumen by the acid produced.
- (l.) On Elsner's (iodine) potato gelatine its colonies are pronounced, brown and large.
- (m.) The bacillus grows well in phenolated gelatine and in phenolated broth.

The typical bacillus coli possesses all these characters, but Mr. Mervyn Gordon, who has been associated with me in this inquiry, has isolated, both from the normal and pathological human intestine, as also from sewage, certain varieties of bacilli which do not give all these tests; which fail, that is to say, in one or the other, or in more than one, of the tests mentioned under (f.), (g.), (h.), (gas bubbles in gelatine shake culture, curdling of milk, and indol production in broth). These we consider provisionally as varieties of bacillus coli.

In addition to this we have, in a few cases, isolated from the human intestine and from samples of sewage, a bacillus which, I consider, owing to its not occurring so frequently as bacillus coli outside the intestine, as of greater value as an indication of excremental pollution than bacillus coli. This bacillus also grows well in phenolated gelatine and in phenolated broth, and its colonies on gelatine are very characteristic; they grow faster than even those of bacillus coli, and are more translucent than those of the latter; they form large translucent patches, angular under a magnifying glass and showing a characteristic white granulation, due to masses of threads, which after 2-3 days is so dense that it makes the colony opaque. The growth is white in reflected, brown in transmitted, light. The bacilli are distinctly cylindrical, non-mobile, and thread-forming. This microbe does not liquefy gelatine, does not form indol in broth, and does not curdle milk. The colonies, when first they appear on gelatine, whether phenolated or not, look like those of bacillus coli, but are distinguished from them by the appearance of white granules under a magnifying glass, and by the morphological differences just mentioned. I regard this bacillus as a variety of proteus Zenkeri.

The Typhoid Bacillus—

- (a.) Typhoid bacilli taken from a recent gelatine or recent agar culture are cylindrical, and form, in many instances, long chains and threads.
- (b.) All show brisk movement in a "hanging drop" of broth, the movement being strikingly more pronounced than in similar cultures of typical bacillus coli.
- (c.) If staining is resorted to, the bacilli are seen covered with long spiral flagella, coming off all along the microbe. The difference between this bacillus and bacillus coli is striking, both as to length, spiral nature, and number of the flagella.*

* PLATE XII., figs. 30 and 31, page 147; and PLATE XIII., figs. 32 and 33, p. 148.

- (d.) The colonies on gelatine resemble those of *bacillus coli*, but are smaller, slower in growing, and more translucent; they do not liquefy gelatine.*
- (e.) The same applies to streak cultures.
- (f.) The typhoid bacillus does not form gas bubbles in gelatine shake cultures.
- (g.) It does not curdle milk.
- (h.) It does not form indol in broth culture.
- (i.) On potato it forms a colourless transparent film.
- (j.) 25 per cent. gelatine incubated at 37° C. is made uniformly turbid by the microbe in 24-48 hours.
- (k.) It produces acid, but conspicuously less than typical *bacillus coli*; and it turns neutral litmus whey red.
- (l.) On Elsner's potato gelatine with iodine it forms conspicuously smaller whitish colonies than *bacillus coli*.
- (m.) Like *bacillus coli* it grows well in phenolated gelatine and phenolated broth.
- (n.) typhoid serum, *i.e.*, blood serum of a guinea-pig immunised (repeatedly injected intraperitoneally) against the typhoid bacillus, gives the Bordet-Durham test with emulsion of typhoid bacillus; that is to say, 1 per cent serum added to bouillon or salt solution, in which scrapings from the surface of an agar culture of typhoid bacillus are suspended, causes aggregation of the bacilli into clumps and their gradual precipitation, so as to leave the fluid clear. With similar emulsion of *bacillus coli* the serum test does not give these results.
- (o.) Pfeiffer's test, *i.e.*, the simultaneous injection of typhoid blood-serum obtained from a highly immunised guinea pig and an otherwise fatal dose of living typhoid culture, into the peritoneum of a healthy guinea-pig, leaves, in the majority of instances, the animal alive (see also my report for 1894-95), whereas the typhoid serum has not as a rule, germicidal effect on culture of *bacillus coli* under like circumstances.

Now, the microbes which in the following experiments will be mentioned as *bacillus coli* or as the typhoid bacillus, are such as possess the differential characters above stated. Although the last, or Pfeiffer's test has not been applied in all cases, it has nevertheless been applied in several with good result. As I have mentioned in a former report, *bacillus coli* and the typhoid bacillus are indistinguishable by animal experiment. Both produce on *subcutaneous* injection into the guinea-pig local tumour and œdema, which lead to necrosis and sloughing of the skin; in large doses either may produce acute septicæmic infection. So, too, intraperitoneal injection of either microbe (one-sixth or one-eighth of an agar culture per 300 grammes guinea-pig) produces acute peritonitis and death in 16-24 hours. The symptoms, appearances, and distribution of the microbes in the tissues I have fully described in a former report, where I have also stated that, compared with other microbes, both *bacillus coli* and the typhoid bacillus are very virulent to the guinea-pig; as a rule, the culture of typical *bacillus coli* obtained from the human intestine is as virulent, if not more so, than that of the typhoid bacillus obtained from the spleen of a case of typhoid fever.

I proceed now to record the results of examination of several batches of oysters tested by me, as to the presence on or within their shells of the microbes that are especially in question.

Examination I.—Two batches of oysters, Nos. 1 and 2, were received from Dr. Bulstrode.

[All the oysters in question were dredged up by me from an estuary in which the oyster layings must needs be exposed in high degree to sewage contamination. Certain of these oysters, indeed, were procured in situations very near to sewage outfalls.—H. T. B.]

From the exterior of the shells of samples from both batches of oysters abundance of bacilli were obtained by the phenol broth process. Some of these bacilli, more particularly from the outside of oysters of batch No. 1, proved on subculture to be typical *bacillus coli*; others, from the outside of oysters belonging in the main to batch No. 2, corresponded in all respects with this micro-organism save for the circumstance that they did not produce gas bubbles in gelatine shake culture. From the interior of none of these oysters was *bacillus coli* obtainable.

Examination II.—Three batches of oysters, Nos. 3, 4, and 5, were received from Dr. Bulstrode.

[The oysters of batch No. 3 were from a "market-pit," on the fore-shore of a creek within the precincts of a small town, situated near to the outfalls of several sewers. Those of batches Nos. 4 and 5 were from "oyster ponds," on the shore of a narrow tidal river, placed close to drain outlets from a large village.—H. T. B.]

As regards one oyster only (batch No. 5) from the three batches, did material from the outside of the shell yield bacteria that could be identified as *bacillus coli*; while from the interior of none of the oysters, though several of each batch were duly examined, could the above *bacillus* or the *bacillus* of typhoid fever be obtained by the culture methods adopted.

Experiment III.—Four batches of oysters, numbered respectively 6, 7, 8, and 9, were received from Dr. Bulstrode.

[The oysters of batches Nos. 6 and 7 were from "market beds" in the seaward portion of an East coast estuary; those of batches Nos. 8 and 9 were from "storage pits" on the foreshore of the same estuary, but within the limits of a small town.—H. T. B.]

Upon the exterior of one only of these oysters (from batch No. 9) was *bacillus coli* discoverable. As regards their interior, the result was also negative, except in a single instance; from one oyster only (batch No. 7) was *bacillus coli* obtained, though in this instance the microbe was present in abundance within the shells.

Experiment IV.—Two batches of oysters, numbered 10 and 11, were received from Dr. Bulstrode.

[Both batches were from the same estuary as those of Experiment III., but from oyster grounds less far removed from shore influences.—H. T. B.]

Upon no oyster from either batch was *bacillus coli* discoverable, and within only one of them could this microbe be detected. In this particular instance, however, it was present in abundance.

Experiment V.—Three batches of oysters, Nos. 12, 13, and 14, were received from Dr. Bulstrode.

[Batch No. 12 was from a "storage pond" on the South coast of England, so placed on the foreshore below high-water mark as to be open to contamination with sewage matters from drains discharging on the beach at no great distance. Batch No. 13 was taken from a sack of oysters recently received in the same locality from "layings" on the East coast. Batch No. 14 was from a "storage

pond" situated on the same beach as that from which batch No. 12 was taken, but far more obviously exposed than the other to sewage contamination.—H. T. B.]

Not a single oyster from any one of these three batches yielded from its exterior or from its interior any microbe identifiable with bacillus coli.

Experiment VI.—Three batches of oysters, Nos. 15, 16, and 17, were received from Dr. Bulstrode.

[All three batches were from "storage ponds" situated near to (and inclusive of) that from which batch No. 12 of Experiment V. had been obtained.—H. T. B.]

Of these three batches every oyster examined yielded from its interior bacillus coli in considerable amount. None of them were tested as to the presence of this microbe on their exterior.

Experiment VII.—Three batches of oysters, labelled respectively "Natives," "Portuguese," and "Deep-sea" were received through Dr. Bulstrode.

[All three batches were from an estuary in the West of England which receives much crude sewage.—H. T. B.]

From no oyster of any one batch was bacillus coli obtained. None of them were examined as to microbes on the exterior of their shells.

Experiment VIII.—Two batches of oysters, Nos. 18 and 19, were received from Dr. Bulstrode.

[Both batches were from "oyster layings" below low-water mark in an estuary on the East coast, but so situated as to be under strong suspicion of contamination by sewage discharged in abundance into the estuary within a mile or two of the spot at which the oysters had been "laid down."—H. T. B.]

From the interior of oysters from both batches bacillus coli was obtained in abundance; also in some of them the variety of proteus Zenkeri that I have referred to. None were examined as to microbes on their exterior.

In addition, oysters were on several occasions bought by me—half-a-dozen at a time—in the London market, and subjected to similar examination. Mainly, they were "natives" of uncertain origin. As a result of my investigation of them, such oysters were not unfrequently found to contain bacillus coli, and now and again proteus vulgaris also.

To this stage of my observation of oysters forwarded to me by Dr. Bulstrode, and all of which I understood in a general way were under more or less suspicion of having been subjected to sewage contamination, I had found but few of these molluscs, comparatively speaking, harbouring bacteria of presumedly undesirable origin. Nevertheless, I had come to infer not only that the oyster does not decline to thrive in water containing sewage, but also that it can now and again receive into its interior, without detriment to its appearance as an article of food, bacteria such as are commonly associated with excremental matters. But so far I had been quite unable to detect within the oysters submitted to me any microbe of a sort definitely deleterious to the human subject; for instance, the most careful study in subcultures of a great number of seemingly doubtful colonies arising in my gelatine plates had not revealed a single specimen of the typhoid bacillus.

At a time when my inquiry in the above sense was approaching its conclusion, I received from Dr. Bulstrode two further batches of oysters

labelled respectively "East River" and "Deep-sea."* Examination of them gave the following results:—The "East River" oysters yielded *proteus vulgaris*, but neither *bacillus coli* nor the typhoid bacillus. As to the "Deep-sea" oysters, one of them yielded in phenol broth a *pure culture* of a motile cylindrical bacillus which proved identical with the typhoid bacillus: In phenol gelatine plate culture, in the aspect of its colonies and as microscopic specimens; in streak culture and in shake culture; in milk and in broth culture; in 25 per cent. gelatine; and in neutral litmus whey culture it was the typical typhoid bacillus. So too when injected, whether subcutaneously or intraperitoneally, into rodents it acted like the typhoid bacillus; and when subjected to the Bordet-Durham test with typhoid serum it behaved like that organism. Finally, tested after Pfeiffer's method by injecting intraperitoneally into the guinea-pig a mixture of culture of this microbe and of typhoid serum, the experimental animal remained unaffected, whereas an equal dose of the culture *minus* the typhoid serum proved fatal in due course to a control guinea-pig. More in detail these experiments were as follows:—

- (1.) One-sixth of a recent agar culture of the typical laboratory typhoid bacillus—originally derived from the spleen of typhoid fever—was injected intraperitoneally into guinea-pig (*a*).
- (2.) One-sixth of the same agar culture was mixed with 0.5 cubic centimetres of typhoid serum, and injected intraperitoneally into guinea-pig (*b*).
- (3.) One-sixth of a recent agar culture of the bacillus of the "Deep-sea" oyster was injected intraperitoneally into guinea-pig (*c*).
- (4.) One-sixth of the same culture was mixed with 0.5 cubic centimetres of typhoid serum and injected intraperitoneally into guinea-pig (*d*).

These guinea-pigs were of about the same size and weighed from 250 to 300 grammes.

The result was very striking; guinea-pigs (*a*) and (*c*) were dead in 20 hours, whereas guinea-pigs (*b*) and (*d*) were quite well and lively next morning; and they remained so.

Staining for exhibition of this microbe's flagella was carried out by Mr. Mervyn Gordon with signal success. The number, spiral shape, and distribution of the flagella on these bacilli "from the Deep-sea" oyster were characteristic of the typical typhoid bacillus.

In view of the importance likely to be attached to the finding of this bacillus in such numbers in one of these East coast oysters, particular care has been exercised in subjecting it to every possible test. Over and over again Mr. Gordon and I have submitted this bacillus to the various tests given above as characteristic of the typhoid bacillus. It has been repeatedly examined in phenol gelatine plates, in streak and stab gelatine, in shake culture, in ordinary and grape-sugar gelatine, on potato, in milk, and in broth; also as to its production of acid in milk, and in broth and neutral litmus whey. We have examined it, too, in various subcultures in the "hanging drop," for determining its cylindrical shape, its formation of filaments, its brisk mobility; and its flagella have been closely studied. In addition, it has been several times subjected to the Bordet-Durham and the Pfeiffer tests with serum of typhoid-immunised animals. As a result, in all and every one of its characters it coincides with the typhoid bacillus obtained from the spleen of a typical case of typhoid fever, and for these reasons I am prepared to affirm that this bacillus obtained from the "Deep-sea" oyster is *the typhoid bacillus*.

* The oysters in question were imported oysters, derived respectively from America and from the North Sea. They had been stored for market at a town on the East coast, in "floats," under circumstances rendering them, in my view, particularly liable to dangerous contamination.—H. T. B.

2.—EXPERIMENTS MADE WITH OYSTERS KEPT IN TYPHOID-INFECTED SEA-WATER.

For the purpose of these experiments, tanks were arranged in the laboratory, each capable of holding about three gallons of sea-water, and fitted with an afferent and an efferent piping fastened into the top part of the tank, so as to allow of either constant or occasional irrigation. In order to effect irrigation, the afferent pipe was connected to an india-rubber tube coming from a large bottle (holding about one gallon) which was fixed at a point about a foot or 18 inches above the tank. By a screw clamp placed on the india-rubber tube, the flow of sea-water from the bottle into the tank could be regulated at will. In practice it was so regulated that the contents of the bottle (about one gallon of sea-water) passed into the tank in about one hour. The efferent pipe of the tank carried the excess of the water away into a pail which contained disinfecting fluid.

The sea-water for experiment was delivered at the laboratory by the Great Eastern Railway Company. Before using, it was strained so as to remove all coarse particles. The tank and the bottle, having been thoroughly cleaned, were filled with this strained sea-water. The oysters for experiment were put under a water tap, thoroughly washed and brushed (with a clean brush) in the stream, dried with clean cloth, and then placed in the tank in a single layer only. Each tank accommodated easily about one dozen oysters. From a recent active culture of the typhoid bacillus (derived from the spleen of a typical case of enteric fever) on solid agar, a distribution in salt solution was made, and the mixture poured into the tank, the contents of which were well stirred up by means of a clean glass rod so as to distribute the typhoid bacilli throughout the water. The tank was then closed with a lid. In some instances the water in the tank was infected by means of culture on the surface (streak) of gelatine of the typhoid bacillus. This was cut up into several pieces and placed amongst the oysters at the bottom of the tank. Every day, except Sundays, the water in the tank was well aerated by stirring up with a clean glass rod for several minutes, after which one gallon of fresh sea-water from the bottle was allowed to pass into, and an equal amount of water out of, the tank. On Saturdays the tank was irrigated with a double dose, *i.e.*, with two gallons of fresh sea-water.

Antecedent to, and concurrently with, observation of oysters under the conditions indicated, experiments were instituted as to the vitality of the typhoid bacillus in sea-water, as follows :—

- (a.) To 200 c.c. of strained non-sterile sea-water contained in a sterile flask there was added a particle of growth from a recent agar culture of the typhoid bacillus; the flask being well shaken, to distribute the microbe throughout the water, and placed in a dark cupboard of the laboratory. Samples of the water were taken from the flask at intervals of one, two, and three weeks, and were dealt with thus: after *one* week, 1 c.c. of the sea-water was added to 10 c.c. of phenolated broth; after *two* weeks, 10 c.c. were added to an equal amount of phenolated broth; and after *three* weeks, the remainder of the sea-water in the flask was added to 189 c.c. of phenolated broth. These broth cultures having been in each instances incubated for 24 hours at 37° C. subcultures were made from them in phenol gelatine plates, and any colonies arising therein that at all resembled the typhoid bacillus were further tested microscopically as film specimens (with flagella staining), and by subculture in different media.

- b.) The sea-water in certain of the tanks to which "typhoid culture" had been added was tested from time to time while the oyster experiments were in progress as to the presence in it of the typhoid bacillus. In each case 100 c.c. of sea-water taken from a tank was introduced into a sterile flask along with an equal amount of nutrient broth, and the whole phenolated to the usual degree. The flask was then incubated at 37° C. for 24 hours and subsequently dealt with as were the broth cultures in (a.) above.

As a result, the typhoid bacillus was recovered from the sea-water in every instance. Even as late as three weeks from commencement of experiment the microbe recovered from the sea-water differed in no way from the typhoid bacillus that had been originally added thereto.

As to the experimental oysters, these were from time to time taken from the tanks for detailed examination. If their shells were well closed, and the oysters therefore living, they were put under the tap, well washed and brushed on the outside, dried in a clean cloth, and opened with a sterile knife. Next, the body of the oyster was well mashed up by means of sterile forceps along with the liquor contained within the shells, and about $\frac{1}{4}$ to $\frac{1}{2}$ c.c. of the liquor and oyster tissue removed by means of a freshly made capillary pipette and introduced into a phenol broth tube, which was incubated at 37° C. for 24 hours. At the end of this period phenol gelatine plates were established from the tube, which were in turn incubated at 20°-21° C. for two or three days. They were then carefully inspected under a magnifying glass, and such colonies as appeared in any way suspicious were further tested as fresh specimens, film specimens, flagella stained specimens, and by subculture in the different media.

Whenever, in the following description, I speak of the typhoid bacillus as having been found, it will be understood to refer to a bacillus which in every one of the characters given above (morphological, cultural, flagella, acid-production, the Bordet-Durham and Pfeiffer's tests) coincides with the characters possessed by the typical typhoid bacillus that had actually been introduced into the water of the tanks.

I may also add that all the oysters examined after residence in the tanks had their valves well and firmly closed, were in good condition, and exhibited ciliary movement on the labial palpi, while their bodies were of normal appearance.

Experiment 1.—"American blue points" bought in the market were placed in a tank, the water of which had been infected with typhoid culture in the manner described. And "Whitstable natives," also bought in the market, were disposed in the same manner in another tank.

Samples of the oysters in both tanks were examined after they had been two days into the typhoid-infected sea-water. The result was that the phenol broth cultures, made from the liquor and oyster tissue, were strongly turbid after incubation for 24 hours at 37° C. The phenol gelatine plates then made from the phenol broth tubes yielded, in due course, numerous colonies which proved to be the typical typhoid bacillus. The next and last examination of these oysters was made after the experiment had been four days in operation. The result was the same, viz., easy detection in their interior of the typical typhoid bacillus.

I intended to subject the remainder of the oysters in both tanks to a further and later examination; but on inspecting them carefully after six days, I was not satisfied with their condition, and therefore discarded them. I was the less surprised at this, seeing that the oysters were bought in the market, and therefore were not of the freshest at starting of the experiment.

From this initial experiment it appears then that four days after infection of the sea-water with typhoid culture, this microbe can be obtained in a living state from the interior of normal looking oysters which have been submitted to the sea-water thus dealt with.

Experiment 2.—"Falmouth natives" bought in the market, were placed, as before, in a tank containing typhoid-infected sea-water. After seven days I opened two of these oysters, and made cultivations in phenol broth of their bodies and of the liquor contained within their snells. From the phenol broth, after 24 hours' incubation at 37° C., I made phenol gelatine plates. From these plates I isolated bacillus coli in large numbers of colonies from both oysters; from one oyster I also isolated numerous colonies which proved the typical typhoid bacillus.

Experiment 3.—Six oysters from each of three lots, forwarded by Dr. Bulstrode, and labelled respectively "American," "French," and "Portuguese," were placed, as before, in tanks containing sea-water that had been infected with the typhoid bacillus. Certain of the oysters were subjected to examination seven days later. The result was that both from the "American" and "French" oysters the typical typhoid bacillus was obtained; as regards the "Portuguese" the result was negative.

Oysters were again taken out from the tanks at the end of fourteen days, when the result of their examination was the same as before, viz., from the "American" and "French" samples the typical typhoid bacillus were obtained, but not from the "Portuguese."

The remainder of the oysters taken out and examined 18 days from commencement of experiment were one "American" and one "Portuguese." The former had its valves tightly closed, and when opened was quite normal in appearance. The "Portuguese" oyster, however, did not look normal; its valves were not well closed, and when the epithelium of its mouth was examined no ciliary movement could be discovered. The result of the culture test was that from the "American," and particularly from the "Portuguese," oyster, the typhoid bacillus was obtained. This "Portuguese" oyster formed then a contrast to the others of the same batch, in which the typhoid bacillus could not be discovered. But it has to be borne in mind that this last "Portuguese" oyster was not in a living condition; and the fact remains that while the "American" oyster after 18 days, the French oyster after 14 days, still harboured the typhoid bacillus in its interior, the Portuguese oyster, while living and in good condition was free of this microbe.

The water of the tank was at this period (18 days after commencement of experiment) examined and tested for the typhoid bacillus, thus:—100 c.c. of the water was mixed with an equal volume of phenolated broth, and incubated at 37° C. for 24 hours. A droplet of the now turbid broth was diluted with a few c.c. of sterile salt solution, and inoculated by means of a platinum loop into phenolated gelatine which was used as a plate cultivation. Several suspicious looking colonies appearing on this plate were submitted to appropriate tests and were found to be the typical typhoid bacillus. The tank water, therefore, still contained after 18 days the living typhoid bacillus, and the abundant presence of it in the dead Portuguese oyster is easily accounted for.

Experiment 4.—Three lots of oysters received direct from Falmouth and labelled "Falmouth natives," "Portuguese," and "Falmouth deep-sea," were placed in typhoid-infected sea-water. An oyster from each lot was examined four days later with the result that from

"Falmouth natives," from "Portuguese," and from "Falmouth deep-sea," the typhoid bacillus was obtained. Thus the previous result as to absence of the typhoid bacillus of experiment from the living Portuguese oyster was not confirmed in this series.

The next examination of these oysters was made after nine days, with the result that from the interior of samples from all three lots of oysters the typical typhoid bacillus was recovered by cultivation. Finally, examination was made of the remainder of the living oysters 17 days from the date of commencement of experiment, viz., of one "Falmouth native" and one "Falmouth deep-sea" oyster. The result was this: that in each case the typhoid bacillus was recovered from the interior of the oyster.

Experiment 5.—Two lots of oysters were received from Dr. Bulstrode, labelled respectively "American" and "Deep-sea" oysters, and were placed in a typhoid-infected sea-water tank.

The first samples were examined after four days, with the result that in both kinds of oyster the typhoid bacillus was obtained from the interior.

Next, oysters were taken out and examined after nine days, the result being that typhoid bacilli were demonstrated in their interior by culture.

The last examination of these oysters was made 16 days from commencement of experiment, only two "American" oysters being available for the purpose, and with the result that from the interior of one of these the typhoid bacillus was still recoverable by culture.

On the same day (17th day of experiment) the tank water itself was subjected to test (100 c.c. of the water being added to 100 c.c. of phenolated broth), and from it a few undoubted colonies of the typhoid bacillus were obtained.

Experiment 6.—The last series of typhoid experiments was made with oysters marked as "East River" and "Deep-sea." They were examined after four days and after nine days' residence in the sea-water tank. On each occasion, from each of the oysters submitted to culture tests, the typical typhoid bacillus was obtained in numerous colonies. There was no difficulty in detecting the typhoid colonies in the phenol-gelatine plates made from the primary phenol-broth cultivations, or in demonstrating the microbes to possess every one of the characters, morphological, cultural, and physiological, belonging to the typical typhoid bacillus.

Before concluding this section of my report, I have to add that a series of experiments were made, both in respect of Bordet-Durham test *in vitro* and with Pfeiffer's test *in corpore*, with the following microbes:—(a) laboratory typhoid bacillus derived from the spleen of a fatal case of typhoid fever; (b) the typhoid bacillus detected by me in an oyster forwarded by Dr. Bulstrode from the East coast; (c) the typhoid bacillus obtained from an oyster that had been exposed by me in typhoid-infected sea-water for four days; (d) the typhoid bacillus obtained from an oyster similarly kept in "typhoid-infected" water for nine days; (e) the typhoid bacillus obtained from an oyster exposed to "typhoid-infected" water for 16 days; and (f) the typhoid bacillus obtained from infected sea-water of the experimental tank 15 days after infection.

As regards the Bordet-Durham test *in vitro*, a distribution in salt solution was made in each instance of a sample of the typhoid bacillus growth from the surface of a recent agar culture, and to this mixture about 1 per cent. of "typhoid serum" was added. The result was definite:

in even half-an-hour the bacilli showed marked aggregation in clumps, and by the end of the hour they had largely settled down leaving the upper portion of the fluid clear. For control experiment, a distribution of bacillus coli was treated in the same way and with the same serum; but no aggregation of the bacilli resulted.

As to Pfeiffer's test *in corpore*, agar surface cultures of each of the above six samples of typhoid bacillus were made and incubated at 37° C. for 48 hours, at the end of which period the following injections were made with a distribution in each instance in bouillon of growth scraped off the agar surface:—(a) one control guinea-pig received one-sixth of a culture per peritoneum; and (b) another guinea-pig received a mixture of one-sixth of a culture and 0.5 cubic centimetres of typhoid serum. This series comprised, then, 12 animals (all about the same weight and all in good condition), of which six were control animals and other six were subjected to Pfeiffer's test. The result was striking and as definite as possible, viz., all six control guinea-pigs were found dead next morning, whereas all the other six animals which received typhoid serum as well as the typhoid bacillus were alive and remained so. It is then clear that in respect of the Bordet-Durham test *in vitro* and of the Pfeiffer test *in corpore*, all six samples of bacilli were of the same nature, viz., they were every one of them the typhoid bacillus.

It follows, therefore, from these experiments that oysters, from various localities and of diverse origin, which are kept for a while in sea-water previously infected with culture of the typhoid bacillus, and which remain living and fresh, may and do harbour in their interior the living typhoid bacillus at intervals of 4, 9, 16, and even 18 days from commencement of experiment; and that these oysters on being opened show no abnormal condition, but appear fresh and quite unaltered. Further, it appears that *the typhoid bacillus which was recovered from these oysters, as also from the tank water, retains unimpaired all the characters of the typical typhoid bacillus that was used for the experiment.*

3.—EXPERIMENTS MADE WITH OYSTERS KEPT IN CHOLERA-INFECTED SEA-WATER.

The oysters referred to under heading No. 1 of this report as having been subjected to bacterioscopic examination for detection of bacillus coli and of the typhoid bacillus, had been at the same time tested (using about a quarter of a cubic centimetre of the liquor and body tissue in each instance), by means of Dunham's peptone salt solution, as to the presence in them of cholera vibrios. But in no case had any organism been found that morphologically or culturally resembled a vibrio. Only in one oyster, an "American" from the East coast, did there appear in the peptone culture (made from the interior of the oyster) a motile microbe which seemed to be comma-shaped and which formed something like  shaped rods. But on subculture in gelatine and on agar this was found to be no true comma, that is no true vibrio. It liquefied gelatine rapidly and formed long threads and cylinders straight or slightly wavy; its character, indeed, in many respects coincided with a variety of proteus vulgaris, though it differed from the typical proteus vulgaris in some important respects. For instance, it does not produce any putrid smell, and even in old cultures preserves the thread form. I discard it, therefore, as a vibrio and place it amongst the proteus varieties.

In order to test the behaviour of the cholera vibrio in oysters the same method was adopted as was used with the typhoid bacillus.

Oysters were exposed in sea-water tanks in the presence of Koch's cholera microbe.

[The cholera vibrio used for infecting the sea-water in the tanks was originally (August, 1894) derived from the rice-water contents (epithelial flakes) of the ileum of a case of typical fatal cholera that had occurred on board a steamer arriving in this country from St. Petersburg. This was one out of several unquestionable cholera cases occurring in seamen that had been in St. Petersburg. The pathological condition of the intestine was typical; the flakes of the rice-water contents of the ileum contained Koch's vibrio in almost pure culture. Tested again immediately antecedent to these experiments, this microbe on culture in peptone and in gelatine plates yielded pure crops of the cholera vibrio; its colonies in gelatine plates were typical;* it gave cholera red reaction in peptone culture; one-tenth to one-twelfth of an agar culture injected into the peritoneal cavity of a guinea-pig produced fatal acute peritonitis with copious exudation filled with the living vibrios. Further, when subjected to the Bordet-Durham test *in vitro* with cholera serum (*i.e.*, blood serum of a guinea-pig highly immunised against the cholera vibrio by repeated previous intraperitoneal injections of non-fatal doses of living cholera culture) it gave positive result; that is to say, salt suspension of the St. Petersburg vibrio to which cholera serum was added showed the characteristic aggregation of the vibrios in clumps and masses which soon settled to the bottom and left the fluid above clear. So also to Pfeiffer's test it gave an affirmative answer. Cholera blood serum being added to an otherwise fatal dose of agar culture of this vibrio, and the mixture injected into the peritoneum of a guinea-pig, death did not result, whereas a control guinea-pig receiving per peritoneum the same dose of the culture, but without the cholera serum, was found dead in 20 hours. This St. Petersburg vibrio has remained then in every respect the true cholera vibrio, though cultures of it had been kept going in the laboratory as "stock cholera vibrio" for a year and a half. At the date of writing its subcultures are found to possess the original morphological and cultural characters of the vibrio unimpaired; and, as recent examination has shown, it responds well to the Bordet-Durham test *in vitro*, as also to Pfeiffer's test *in corpore*.]

A culture of this vibrio having been made on the surface of nutrient agar, and incubated at 37° C. for two days, the growth was scraped down in sterile salt solution and this was poured into the sea-water in a tank, one culture to three gallons. The oysters were then placed in the tank, and irrigation with a fresh gallon of sea-water and aëration were carried out daily, just as in the case of the experiments with the typhoid bacillus.

A preliminary series of experiments was made with regard to testing the vitality of the cholera vibrio in sea-water, such as was about to be used for the tanks; that is to say, non-sterile sea-water, strained and unstrained. Having first ascertained by culture that the sea-water was free of any kind of vibrio, to flasks containing each about 200 cubic centimetres of the sea-water a good loop full of cholera vibrios were added from the surface growth of a recent agar culture. The sea-water was then tested after 4, 6, 8, 12, and 14 days by the peptone culture method, always using larger and larger volumes of the water as time went on. Thus, after a whole fortnight's sojourn of the vibrio in the sea-water, 90 cubic centimetres, or even double that quantity of water, was taken from the flask, and to it were added 10 cubic

* PLATE VII., fig. 7, page 142; PLATE VIII., figs. 8 and 9, page 143; and PLATE XIII., fig. 34, page 148.

centimetres (or 20 cubic centimetres) of a stock fluid containing 10 per cent. peptone, and 5 per cent. of salt in water, with the result that the final mixture contained peptone 1 per cent. After incubating this mixture for 24–48 hours at 37° C., the surface layers of the now turbid fluid were tested in the usual manner by microscopic examination and by gelatine and agar plate subculture. As soon as colonies appeared in these plates they were used for making stab gelatine and further peptone cultures, the latter after 24 hours being tested for cholera red reaction.

In this way it was ascertained that, after a fortnight, cultivable cholera vibrios were still obtainable from the sea-water, and the conclusion, therefore, is justified that the cholera vibrio can retain its vitality certainly for 14 days in non-sterile sea-water. Further, it was ascertained that under the above conditions this microbe retained its general morphological and cultural characters unimpaired, with the exception only that the individual vibrios were extremely short.

While the above was the general result of testing non-sterile sea-water kept in flasks that had been infected from a recent cholera culture, it deserves notice that there was one series of experiments in which the result was somewhat different, as follows:—

(1.) To 200 cubic centimetres of the strained non-sterile sea-water contained in a sterile flask (which water had been proved by cultivation to be barren of comma-bacilli) there was added a particle of a growth 48 hours old of the cholera vibrio on the surface of agar; the flask was then well shaken and put away in a cupboard.

(2.) To another 200 cubic centimetres of the same strained non-sterile sea water there was added a particle of a pure growth of the cholera vibrio on the surface of agar, which had been incubated at 37° for ten days, the flask being then, like the other, well shaken and placed away in a cupboard. The ten days old agar culture in question, when examined under the microscope in the fresh condition, exhibited very few motile commas, the majority seemed degenerating, granular or swollen up.

Flask 1 was tested eight days later by adding to it 22 cubic centimetres of a stock peptone salt solution (10 per cent. peptone, 5 per cent. salt) and incubating it at 37° C. Next day the fluid in the flask being distinctly turbid, from the top layer plate cultivations were made, and in these plates numerous colonies of cholera vibrios came up, which, tested in subculture, possessed all the characters of the typical cholera vibrio.

Flask 2 was tested in like manner after 11 days by adding to it 22 cubic centimetres of the same stock peptone salt solution and incubating it at 37° C. The fluid in the flask was slightly turbid in 24 hours, and from the top layer a plate cultivation was made. In this, one colony of liquefying motile commas came up, which, when tested by subcultures, furnished a vibrio resembling the typical cholera vibrio in some respects, but differing from it in others. Morphologically, as regards its motility, and as regards flagella, it did not differ from the laboratory cholera vibrio, except perhaps that in recent peptone culture the individual commas appeared a little thicker and that spirals made up of short commas were more numerously met with than is the case in similar recent peptone cultures of the typical cholera vibrio. In gelatine plate, in gelatine stab (after some days of liquefaction it forms a thick pellicle in the stab culture), on agar plates, and in agar surface culture (both the latter incubated at 20° C.), there is no perceptible difference between this sea-water vibrio and the parent cholera vibrio. But they do differ in the circumstance that the former does not grow at 37° C. either on

agar or in peptone, though it shows good growth in these media at 20° C. And in peptone, which is turbid already after 24 hours, it forms flocculi, but fails to give any cholera red reaction. In the above respects this sea-water vibrio corresponds so closely to a vibrio which will be described later, as obtained from the sea-water of one of the oyster tanks 13 days after the water had been infected with the St. Petersburg vibrio, that I consider them very closely related. It will be again referred to later on as vibrio No. 4.

Experiment 1.—Oysters received direct from Falmouth, and labelled “Falmouth natives,” “Falmouth deep-sea,” and “Falmouth Portuguese” (see also Experiment 4, page 118), were placed in tanks of sea-water that had been infected with the cholera vibrio in the way already described.

The oysters were first examined *four* days after having been placed in the cholera-infected sea-water, by culture in peptone salt solution of a small amount of mixed oyster-body and oyster-liquor. The oysters appeared quite normal, fresh, and living. After 24 hours' incubation at 37° C., the peptone cultures of each sort of oyster being turbid, from the surface layers fresh and stained film specimens were made, with the result of finding that each sample of the peptone salt solution in question was an almost pure culture of vibrios which, in motility, in size, and in shape, could not be distinguished from the cholera vibrio.* Ordinary gelatine plates were next made from these peptone cultures, and in these practically all colonies were of the same character. After two to three days' incubation at 20° C. colonies appeared as circular translucent grey dots, each slightly sunk in a pit due to commencing softening of the gelatine in a circular narrow clear zone. Examined as fresh and stained film specimens under the microscope, the colonies were found to be made up of very pronounced actively motile commas and $\hookrightarrow$ -shaped vibrios, with here and there also a longer spirillum. After five to seven days the liquefaction was distinct but far less than was the case in a comparison plate of the St. Petersburg vibrio; in the latter the liquefied area formed around each colony was several times as large, and the growth showed, moreover, the characteristic granular glass-splinter-like deposit, whereas each colony from the above oysters was very much less extensive, the liquefied zone was perfectly limpid, and the growth was limited to a central grey disc-shaped or slightly convex aggregation. From these colonies subcultures were therefore made: (a) in peptone, (b) in gelatine stab, (c) in gelatine streak, (d) on agar, and (e) in milk. (a.) The peptone cultures after 24 hours' incubation at 37° C. were tested with pure sulphuric acid, and they gave distinct cholera red reaction. (b.) The stab cultures showed good growth after two days in the form of a line of closely placed small globules; but even after five or six days there was no trace of liquefaction. After a week the upper part of the stab began to be drawn in and then liquefaction began, but very slowly and progressed very slowly; after about nine to ten days there was the characteristic funnel-shaped air bubble at the upper end of the stab, and liquefaction proceeded from here. The progress of the liquefaction was therefore in these oyster vibrios greatly delayed as well as very much slower than in the comparison tubes of the original St. Petersburg vibrio. Another striking difference between the two vibrios was this: As regards the St. Petersburg vibrio, after liquefaction in the stab culture had involved nearly half of the gelatine in the culture tube—*i.e.*, after about 10 to 14 days—the liquefied gelatine was only slightly turbid, and at this stage the culture showed the usual small granules in and on the sides of the funnel

* PLATE XIII., fig. 35, page 148.

of liquefaction, on the surface an indication only of filmy pellicle, and at the bottom a voluminous white powdery precipitate. In the oyster vibrio, after liquefaction had well progressed, in, say, about three weeks, the liquefied gelatine was clear, but the surface was covered with a thick white pellicle; at the bottom of the liquefied gelatine were the usual voluminous flocculi and granules. (c.) Also in streak culture the oyster vibrio showed a marked difference from the St. Petersburg vibrio; the liquefaction in the streak culture of the oyster vibrio was as rapid as in the St. Petersburg vibrio, but the surface growth in the former was a continuous, fairly coherent, white membrane. (d.) On agar at 37° C. there was no difference between the two vibrios, nor was there any essential difference in milk or on potato. (e.) Milk at 37° C. is coagulated by the St. Petersburg vibrio in eight days, by the oyster vibrio it is coagulated in five days.

The difference between the two vibrios was then pronounced—(a) in gelatine plate, (b) in gelatine stab, and (c) in gelatine streak or surface culture; and so marked was this difference that by comparing their cultures in parallel series no one could fail to notice it.

Moreover, I have tested the two vibrios from culture to culture through more than a dozen subcultures. I have passed them also through the peritoneal cavity of guinea-pigs for more than 12 consecutive transmissions, and, as at starting so also in the end, the differences remained the same. I have made peptone, plate, and stab cultures from the peritoneal exudation of every one of the guinea-pigs (the animals died in each case 20–24 hours after injecting one-fourth of an agar culture); and, as in the first so in the last of the series, stab cultures of this oyster vibrio showed for the first five or six days no trace of liquefaction—then only they began to show a drawing in of the gelatine at the upper end of the stab. In my report respecting cholera in England (1893) I have, amongst different varieties of the cholera vibrios cultivated from the contents of cholera intestines, described one (Southwark Case, No. XXXIX., p. 183) in which the same greatly delayed and extremely slow liquefaction of the gelatine in stab culture was noticed; but the above oyster vibrio is even slower than that of the Southwark case. It is curious too to see the great influence that the free access of air has on liquefaction of the gelatine by this oyster vibrio; for in gelatine surface (streak) culture the liquefaction is as quick as in the case of the St. Petersburg vibrio, but if from such a surface culture a gelatine stab culture be made there is again no liquefaction for about the first week.

It appears then that from the interior all the three kinds of oysters which came from Falmouth, and which had been kept for four days in cholera-infected water, vibrios were obtained which, although possessed of some of the characters of the typical cholera vibrio that was used for the experiment, nevertheless in some important respects (aspect of colonies in plate, nature of stab and surface gelatine cultures) were markedly different, and that these differences remained stable through all further transmissions, not only in artificial cultures but also in the guinea-pig. I am justified, therefore, in speaking of this vibrio as a variety of the original St. Petersburg vibrio, and shall designate it oyster vibrio No. 1, in order to distinguish it from the former in future discussion.*

As regards the physiological activity of this oyster vibrio No. 1, on the guinea-pig, it was found that this was slightly less than that of the St. Petersburg vibrio. Of the St. Petersburg vibrio one-eighth, or even one-tenth, of an agar culture (incubated 48 hours at 37° C.)

* PLATE III., fig. 3, page 138; PLATE VIII., figs. 10, 11, 12, and 13, page 143; and PLATE IX., figs. 14, 15, 16, and 17, page 144.

suffices to produce, when intraperitoneally injected into a guinea-pig of about 300 grammes weight, death in 20 hours; whereas of the oyster vibrio No. 1, one-fifth, or even one-fourth, of a culture is required to produce a like effect. But the symptoms during life, and the pathological appearances after death, are, as in other intraperitoneal injections of various microbes, the same, viz., acute peritonitis, with more or less copious, more or less turbid and sanguineous, exudation crowded with the microbe used for injection;* the serous covering of the intestine is injected; the surface of the liver, stomach, and omentum is covered with solid lymph; the small intestine is relaxed, and contains sanguineous mucus and numerous epithelial flakes.

In using this oyster vibrio No. 1 (as also the St. Petersburg vibrio) for intraperitoneal injection in doses which produced death in 30 or 36 hours, it is found that the peritoneal fluid furnishes numerous leucocytes containing vibrios in their interior, either still comma-shaped or as smaller or larger globules. In these cases I have generally found that the intestinal mucus and the epithelial flakes contain the vibrios of experiment in great numbers. By peptone cultures I have in several instances isolated the oyster vibrio No. 1 from the intestinal contents, but I always found that it, and its subcultures, possessed and retained the same differential characters; that is to say, no matter whether from the peritoneal exudation or from the intestinal contents of the guinea-pig, its characters, *i.e.*, the altered aspect of its colonies in plate, its slow liquefaction in stab, and its membranous liquefying growth in streak gelatine culture, persisted.

The next oysters of this batch that were examined were removed from the tank of cholera-infected sea water *nine* days after commencement of experiment. Peptone cultures were made as before from the body and liquor of the oysters, and were incubated 37° C. for 24 hours. Examining a droplet in each instance from the upper portion of the peptone culture in fresh and in stained film specimens, comma-bacilli and $\hookleftarrow$ forms were seen. In the peptone culture from a "deep-sea oyster" the culture seemed to contain a very large number of vibrios, the other two sorts of oyster ("natives" and "Portuguese") were now strongly contaminated with straight bacilli. I made, therefore, plate cultures from the peptone culture of the "deep-sea" oyster only.

When examining stained film specimens of a peptone culture of this "deep-sea" oyster a difference was at once noticed between the vibrios now obtained and the St. Petersburg vibrio of a similar peptone culture. The difference was that of this oyster vibrio No. 2 the commas, as also the $\hookleftarrow$ -shaped forms and the spirals, were markedly pointed at their ends. This was particularly noticeable as regarded the $\hookleftarrow$ forms, these latter forming a great preponderance.† That this oyster vibrio No. 2 was also in other respects different from the St. Petersburg vibrio was demonstrable in the plate and in other subcultures.‡

In plate cultivation oyster vibrio No. 2 exhibits liquefaction with about the same rapidity as the St. Petersburg vibrio, but the growth in the whole extent of the liquefied zone forms a more or less concentric white continuous mass, quite unlike a typical colony of the St. Petersburg vibrio. Under the microscope, in stained film specimens, are seen numerous $\hookleftarrow$ forms, short spirals, a few single commas, and numerous circular forms.

* PLATE XIV., figs. 36, 37, and 38, page 149.

† PLATE XIV., fig. 39, page 149; and PLATE XV., fig. 40, page 150.

‡ PLATE X., figs. 20, 21, and 22, page 145.

In gelatine stab culture the appearances as to liquefaction and superficial air bubble are the same as in the St. Petersburg vibrio, with the marked exception that in the case of oyster vibrio No. 2 the liquefied gelatine is almost transparent with a relatively small amount of greyish floccular precipitate. These characters distinguishing oyster vibrio No. 2 from the St. Petersburg vibrio, viz., aspect of the colonies in the gelatine plate (concentric, whitish, extensive masses), and transparency of the liquefied gelatine in the stab gelatine culture, remain constant through repeated subcultures.

Still more surprising is the character of oyster vibrio No. 2 on agar. It grows on agar at 20° C. as extremely translucent flat colonies, little noticeable to the unaided eye after two or three days, and requiring inspection with a glass; after a week or more the growth is distinct but still translucent. In stained film specimens the vibrios are seen chiefly as longer or shorter more or less wavy filaments; but there are amongst them commas and } forms.

On agar incubated at 37° C., very little growth is produced, in fact it may be said that Vibrio No. 2 practically does not grow at this temperature. But I have succeeded in getting it to grow on agar at this temperature by continued transference at intervals of two to four days from one hot agar culture to another; the growth, however, though distinct, could not be called extensive, and even in the tubes in which the whole line of inoculation became covered with growth—a band of a few millimetres breadth—after incubation at 37° C. for 2-3 days, the growth was markedly transparent, and when trying to take up some of it with a platinum needle or loop it was found to be slimy and cohesive. In fresh and in film specimens it consisted of longer or shorter wavy threads, a few } forms, and very numerous globules of various sizes, probably degenerated forms.

This oyster vibrio No. 2 does not grow in peptone salt solution, neither at 20° C. nor at 37° C., and therefore no cholera red reaction could be tested. This refusal of it to grow in peptone is the more astonishing, since originally the vibrio was obtained from a peptone culture that had been incubated at 37° C. (made direct from the interior of the "deep-sea oyster"). In this culture, however, other microbes were present, and these may have had something to do with the result; the fact remains, however, that although I have repeatedly tried from various subcultures to grow this oyster vibrio No. 2 in peptone, hot and cold, I have hitherto failed.

A number of experiments were made with oyster vibrio No. 2 on the guinea-pig, using agar cultures (incubated at 20° C. or at 37° C.) for intraperitoneal injection. The growth of a whole culture tube, incubated at 20° C., was injected into a guinea-pig of about 200 grammes weight, with the result that the animal appeared very ill the same evening, but had recovered next morning. Similar growth from an agar tube incubated at 37° C. was injected intraperitoneally into a small guinea-pig. The animal was very quiet in the evening, huddled up in the corner of the cage: it was found dead next morning. In the peritoneal cavity was copious strongly sanguineous but liquid exudation, in film specimens of which no leucocytes and no microbes could be recognised. Cultivations of the exudation were made on agar and incubated at 37° C., and a few colonies of the transparent character and the morphological nature already described were obtained.

It is then clear that this oyster vibrio No. 2 is totally different from the St. Petersburg vibrio and also from oyster vibrio No. 1.

The first question, therefore, that suggests itself is this: Are these three vibrios—St. Petersburg vibrio, oyster vibrio No. 1, and oyster vibrio No. 2—in any way related to one another?

Considering that the St. Petersburg vibrio is so utterly unlike in cultural respects oyster vibrio No. 2, one would have at first sight little hesitation in pronouncing them two distinct and different species. Oyster vibrio No. 1 would be likewise declared different from the St. Petersburg vibrio on account of the marked difference in the growth and aspect of its colonies in gelatine plates and in gelatine streak, and because of its non-liquefaction of this medium in stab culture. But in this respect it is necessary to bear in mind the former experience of the Southwark vibrio; besides, oyster vibrio No. 1 in another respect, *i.e.*, in cholera red reaction, behaved itself like the St. Petersburg vibrio.

Now, either of two views may be advanced concerning the nature of oyster vibrios No. 1 and No. 2.

(1.) That these two vibrios, possessing as they do well-marked characters, and maintaining these definite differences in subsequent subcultures, are species different from the St. Petersburg vibrio; that they stand in no sort of relation to this latter. Under this aspect they would be vibrios pertaining to the oyster *per se* or to the sea-water in the tank.

And (2.) That the St. Petersburg vibrio originally added to the tank water having become embodied in the oysters, had, owing to its sojourn there and to the action of the oyster tissue, been so modified as to assume different characters, in consequence of which its progeny came to markedly differ from their parent.

On the first view it must seem strange that in none of the oysters which were examined previous to placing their fellows in the tank water was I able to discover anything like a vibrio. Moreover, I had not been able to find any vibrio in the sea-water itself previous to adding to it the culture of the St. Petersburg vibrio. How then, it will be asked, did I find no difficulty by the same method (peptone salt solution) in obtaining the above vibrios in culture from the interior of the oysters, after having kept them in the infected sea-water? Another point of still greater importance is this: In every one of the oysters ("native," "Portuguese," and "deep-sea") taken out of this tank after four days, oyster vibrio No. 1 appeared at once in the peptone culture, so that under this aspect of the matter the problem as to oyster vibrio No. 1 would have to be stated thus: Of a given batch of oysters from the same source, every one examined, *before placing any in infected sea-water*, by peptone salt culture yielded negative result, whereas every one examined, by peptone salt culture, four days *after being placed in cholera-injected water* yielded abundance of vibrios; which vibrios on subculture appeared to belong to one and the same variety, but which nevertheless possessed at the outset, and maintained through all subsequent subcultures (artificial media and peritoneal cavity of the guinea-pig), certain well-marked cultural differences from the St. Petersburg vibrio. I think, looked at in this light, I am justified in concluding that the second alternative is the right one, *viz.*, that oyster vibrio No. 1 was really derived from the St. Petersburg vibrio, and that it had assumed its characteristic and definite differences while within the oyster. And I am the more inclined to such conclusion since the observed cultural differences between it and the St. Petersburg vibrio, though distinct, are not more pronounced than those already known, and which I myself have described, as appertaining to cholera vibrios derived from the intestines of different cholera cases in 1893. The difficulty in regarding oyster vibrio No. 1 as the offspring of the

St. Petersburg vibrio lies, it seems to me, not so much in the existence of its differences in plate, stab, and streak culture, as in the fact that these differences had become permanent. Be it remembered, however, that in this respect the varieties of cholera vibrios cultivated by me from different cholera cases in 1893 were of a permanent character.

As far as I can see this is the first instance in which one definite and typical cholera vibrio (St. Petersburg vibrio) has been transformed into another and culturally different vibrio; this change having been effected through the medium of the oyster in four days. It is true that there have been statements made by Sanarelli as to the relation of certain varieties of vibrios found in waterways in and around Paris to cases of Asiatic cholera that had occurred one or two years previously in these localities, and that these several varieties have been carefully investigated by Sanarelli. But the descent of his water vibrios from the true cholera vibrio is in the nature of the thing merely an inference. In various other waters too, of the Danube, Spree, Elbe, &c., varieties of vibrios have been found in years following cholera years, and the differences between these vibrios and the cholera vibrio have been carefully described, with the result that they have been declared not to be cholera vibrios. I shall have to return to this point later on more fully, after having given some further account of my observations of oysters; but here I would wish merely to add that from the above observations made on oyster vibrio No. 1, the statements that have been made to the effect that various water vibrios must not, because of the permanent cultural differences between them and the typical cholera vibrio, be regarded as related to the cholera vibrio, cannot be accepted for a moment as necessarily correct.

As regards oyster vibrio No. 2 (obtained from a "deep-sea" oyster after nine days in infected water), though it may be premature to consider it as a modified St. Petersburg vibrio, its cultural and biological characters being so very far removed from those of the cholera vibrio, yet there is the fact that it was obtained from an oyster after the latter had been nine days in cholera-infected water. Further observations are required, particularly experiments with agar cultures (incubated at 37° C.) on animals, before coming to a definite conclusion on this point.

Experiment 2.—Two batches of oysters, "American" and "deep-sea," were received from Dr. Bulstrode. Two oysters of each batch were used for cultivation in peptone salt solution before placing the rest in the tank, the sea-water in which had been infected with recent cholera culture as in the first series. The result of these cultivations of these two fresh oysters was negative *qua* vibrios, except that from the "American" sample (as was mentioned at the commencement of this section) the peptone culture developed a growth resembling somewhat comma-shaped bacilli. These, however, on subculture were clearly no vibrios, but most likely a variety of *preteus*.

The first oysters of this experiment were examined *four* days after having been placed in the cholera-infected water.

The peptone cultures after 24 hours' incubation were uniformly turbid, and in stained film specimens therefrom numerous vibrios, commas, ^{hook} forms, and short spirals could be distinguished, and amongst them straight bacilli. Plate cultivations in gelatine were then made and incubated at 20° C. An inspection of these after two days showed numerous liquefying circular colonies, each in a depressed circular area of liquefied medium, clear in the peripheral part, white in the middle part, with an aggregation of greyish white masses in the centre. Examined under the microscope in fresh and in stained film specimens, the growths

appeared composed of rapidly motile well-curved commas, }-shaped forms, and particularly numerous well-twisted spirilla, some of these of great length. From such colonies subcultures were made in further plates, in gelatine stab, on agar, and in peptone. The vibrio here dealt with, derived from an "American" oyster after being kept four days in cholera-infected tank water, may be designated for identification as oyster vibrio No. 3. As a result of study of this vibrio in subculture in the various media, the following are its characters as contrasted with the St. Petersburg vibrio :—*

(1.) Oyster vibrio No. 3 grows distinctly faster, and liquefies gelatine in the plate conspicuously more rapidly than the St. Petersburg vibrio. (2.) The aspect of the colony in the plate differs also from that of the St. Petersburg vibrio in not showing the glass-splinter-like granules ; in the liquefied area the growth forms a central, more homogeneous, whitish grey collection. (3.) In stab gelatine culture the stab of inoculation shows as early as after 24 hours distinct funnel-shaped liquefaction ; the liquefied gelatine is turbid, and the surface, *i.e.*, the upper end of the stab, funnel-shaped and occluded by an air bubble. After 2-3 days the liquefaction is far advanced, nearly as advanced as in a similar culture of the Finkler-Prior vibrio, and the liquefied gelatine has become turbid ; in fact, in the stab culture this vibrio is more like the Finkler-Prior vibrio than the St. Petersburg vibrio, but there is no smell perceptible in the gelatine cultures of oyster vibrio No. 3. (4.) Peptone is made considerably more turbid in 24 hours at 37° C. than is the case with the St. Petersburg vibrio. (5.) On agar at 37° C. oyster vibrio No. 3 grows like the St. Petersburg vibrio, but much faster. (6.) Peptone cultures do *not* show cholera red reaction. (7.) It coagulates milk at 37° C. like the St. Petersburg vibrio, but a little quicker (six days). (8.) Compared under the microscope oyster vibrio No. 3 is decidedly thicker and longer than the St. Petersburg vibrio, both being taken from a recent colony in a gelatine plate.

Oyster vibrio No. 3 differs then from the St. Petersburg vibrio in as many different points as did oyster vibrio No. 1. Amongst these the more rapid liquefaction and greater turbidity of the liquefied gelatine, the failure in giving cholera red reaction in peptone culture, and the different aspect of the colonies in gelatine plates are its most noteworthy differential characters.

In morphological respects oyster vibrio No. 3 is a finer, that is, more pronounced, vibrio than the St. Petersburg vibrio ; its rapid formation of long, plicated, well-twisted spirals being a noteworthy character.† These characters of oyster vibrio No. 3 were ascertained, not only in the early but in all later subcultures. They remained permanent. And not only was this the case in artificial culture, but these characters were transmitted through a long series of guinea-pigs per peritoneum, remaining the same from first to last. Oyster vibrio No. 3 is virulent to guinea-pigs when injected into the peritoneal cavity ; one-sixth, one-eighth, and even one-tenth of the growth from the slanting surface of a recent agar culture suffices to produce acute peritonitis in a guinea-pig weighing about 300 grammes, which is fatal in 20 hours. The peritoneal exudation is copious, thick, viscid, turbid, slightly sanguineous, and densely crowded with vibrios, amongst which strongly-curved semi-circles to almost complete circles are conspicuous. The small intestine is much congested, relaxed, and filled with sanguineous mucus, in which

* PLATE V., fig. 5, page 140 ; and PLATE IX., figs. 18 and 19, page 144.

† PLATE XV., figs. 41, 42, and 43, page 150.

large and small detached epithelial flakes are noticed; but within the intestine, neither microscopically nor culturally could any vibrios be discovered.*

From the peritoneal exudations of the guinea-pigs that succumbed to oyster vibrio No. 3 cultures were made; and with these cultures further guinea-pigs were intraperitoneally injected, causing, as before, peritonitis and death of the animals. In this manner more than a dozen successive transmissions were carried out. The cultures obtained from the peritoneal exudation of every one of these guinea-pigs were tested as to the characters of the vibrio, and from first to last they were found the same, there was no alteration observed in any of them.

It would appear then that the "American oyster" from the East coast had also transformed the original St. Petersburg vibrio into a definite variety or species, viz., oyster vibrio No. 3. Leaving out oyster vibrio No. 2 (from the Falmouth "deep-sea oyster" after nine days) for the present, as not yet sufficiently investigated, and limiting consideration to the three vibrios—St. Petersburg cholera vibrio, oyster vibrio No. 1, and oyster vibrio No. 3—these may be placed in the following genealogical table as regards cultural characters:—

St. Petersburg Cholera Vibrio, Parent.

Oyster vibrio No. 1 (from oyster four days in tank). Chief differential characters:—	Oyster vibrio No. 3 from oyster four days in tank). Chief differential characters:—
(a.) extremely retarded liquefaction in stab;	(a.) grows much faster in plate and stab;
(b.) conspicuously retarded growth in plate;	(b.) liquefies gelatine very fast in stab, and the liquefied gelatine is uniformly turbid;
(c.) central grey disc-shaped growth, periphery clear, liquefied area of colonies;	(c.) grows faster in peptone and agar;
(d.) gives cholera red reaction; coagulates milk in five days.	(d.) does not give cholera red; curdles milk in six days.

Both these vibrios were derived from oysters, but from different lots and from different tanks, kept four days in cholera-infected sea-water. Both these vibrios (Nos. 1 and 3) differ in gelatine cultures from the St. Petersburg cholera vibrio to about the same extent, but not in the same direction, rather in opposite directions. No. 1 grows slower, No. 3 grows faster than the St. Petersburg cholera vibrio; No. 1 shows much retarded, No. 3 shows much accelerated, liquefaction. As regards cholera red reaction, No. 1 gave it just like its parent, No. 3 had loss it. No. 3 was as virulent on the guinea-pig's peritoneum as the parent, No. 1 was less virulent. Both No. 1 and No. 3 curdled milk faster than the parent.

* This condition of the intestine, viz., copious mucus with detached epithelial flakes is often observed in the congested small intestine of guinea-pigs dead from acute peritonitis, produced by intraperitoneal injection of various microbes: not only of cholera vibrios, but of many others—as, for instance, bacillus prodigiosus, bacillus coli, the typhoid bacillus, vibrio of Finkler, proteus vulgaris, and others. R. Pfeiffer seems to think ("Zeitschrift für Hygiene und Infektionskrankheiten," Vol. xvi.) that the presence of detached epithelial flakes in the intestine is special to and solely the result of the activities of the cholera vibrio in the intestine of such intraperitoneally injected guinea-pigs. But this is a mistake. Fatal peritonitis produced by intraperitoneal injection of other microbes is accompanied by similar condition of the intestine, no matter whether the particular microbe injected into the peritoneal cavity does or does not find access to the intestinal cavity. The shedding (death) of the epithelial lining of the intestine is, therefore, evidently a result of the peritonitis and enteritis, and not directly of the presence of the microbe in the intestinal cavity.

From the same batch of East coast oysters, some were tested *nine* days after the beginning of experiment by peptone cultures, but the success was questionable. It is true there were in the cover-glass specimens distinct commas and $\hookleftarrow$ shaped forms, also a few spirals, but they were so swamped by straight spore-bearing pellicle-forming bacilli that further isolation of the vibrios failed.

Examination of the Tank Water infected with Cholera vibrio.

(1.) While the above experiments were proceeding my attention was also directed to the cholera-infected sea-water in the tanks in which the oysters were being kept. Having ascertained by previous experiments that in test tubes and flasks the cholera vibrio retains its vitality in sea-water for 14 days, I was interested to learn how the cholera vibrio behaved in the water of the oyster tanks. I therefore took out at the end of *four* days from the tank containing the "Falmouth" oysters, that is, those from which oyster vibrio No. 1 was obtained, 90 cubic centimetres of the water, which I placed in a sterile flask. To the water in the flask there were added 10 cubic centimetres of a stock solution containing 10 per cent. peptone, 5 per cent. salt, and the mixture incubated at 37° C. for 24 hours. The contents of the flask were now turbid, and microscopic examination, in fresh and stained film specimens, made from the upper portion of the fluid, showed abundance of very short vibrios. Plate cultivations in gelatine were next made, and colonies of typical cholera vibrios were obtained, which in subcultures proved in no way different from the St. Petersburg vibrio that had been originally added to the tank water, except that the commas and $\hookleftarrow$ forms were distinctly shorter than those of the St. Petersburg vibrio from the same kind of cultures. This conspicuous smallness of the tank-water vibrio persisted, not only in subcultures in artificial media but also in the peritoneal exudations of experimental guinea-pigs and in the cultures therefrom.*

(2.) From the tank in which the oysters of experiment No. 2 had been kept *13 days* in sea-water infected with the cholera vibrio, 90 cubic centimetres of water were removed and placed in a flask along with 10 cubic centimetres of the above stock (10 per cent.) peptone solution. The flask was then incubated at 37° C. for 24 hours. Microscopic specimens made of the upper portion of the fluid at this stage showed numerous vibrios—commas, $\hookleftarrow$ forms, and particularly long, well twisted spirilla. By plate cultivation colonies of this vibrio were easily isolated with characters as follows:—(a) its colonies liquefy gelatine in the plate faster than the parent St. Petersburg vibrio; (b) the liquefied gelatine is less turbid and more uniform—absence of glass-splinter-like granules—than the parent vibrio; (c) in stab gelatine the tank-water vibrio liquefies conspicuously more rapidly than its parent, and the gelatine is more transparent; on the top of the gelatine there is already, after two days, a coherent, thick, white pellicle; (d) the tank-water vibrio does not grow in peptone at 37° C., but grows very rapidly in peptone at 20° C., making it turbid in 24 hours, with appearance of numerous grey flocculi; (e) it does not grow on the surface of agar at 37° C., but at 20° C. forms a slimy, sticky, whitish growth in 24 hours, therefore growing conspicuously faster at 20° C. than the St. Petersburg vibrio; (f) it does not give cholera red reaction; (g) it forms exquisite long spirilla, already, after 24 hours, from peptone at 20° C., or from the surface pellicle of gelatine. In fresh or stained

* PLATE IV., fig. 4, page 139; PLATE XI., figs. 25 and 26, page 146; and PLATE XVI., figs. 44 and 45, page 151.

film specimens, numerous rapidly motile, wavy, or well-twisted spirilla are present.*

As mentioned above, this vibrio, which will be hereafter referred to as vibrio No. 4, grows rapidly on the surface of agar at 20° C., forming within 24 hours, a continuous membranous expansion. One-fourth of a culture was injected into the peritoneal cavity of a guinea-pig, but the result was nil. I next injected a whole culture into the peritoneal cavity of a guinea-pig. The animal was quiet and ill the same evening; and was more so next morning, not feeding, and sitting huddled up in the corner of its cage. As I was desirous of seeing what was the actual condition of the vibrios in this animal's peritoneum, the animal was killed with chloroform, and a post-mortem was made. The peritoneum and the serous coat of the abdominal viscera were congested, and upon them was extremely viscid turbid exudation. Under the microscope this was found full of leucocytes; but neither in fresh nor in stained film specimens was there anything like a vibrio or other microbe distinguishable in or outside the cells. Cultivations of the exudation were made in peptone and on gelatine and agar, using for each culture a good-sized drop, and incubating the cultures at 20° and at 37° C. respectively. The result was negative, no growth of any kind was obtained in any of the tubes.

Here then, in vibrio No. 4, is a further variety, obtained from the sea-water of a tank in which, previous to infection with the St. Petersburg cholera vibrio, no vibrio of any kind could be demonstrated; yet 13 days later, by the same method which failed before, a vibrio is easily isolated, which utterly differs from the cholera vibrio that was placed in the tank.

As a result of these observations on oysters there are obtained a variety of vibrios, all apparently derived from one parent stock, the St. Petersburg cholera vibrio, but differing from it in one or more characters—morphological, cultural, and physiological; these differences being maintained unaltered in subculture. They are—

- | | |
|----------------|---|
| Vibrio No. 1.— | “Falmouth” oyster, after 4 days in sea-water tank.) |
| ” 2.— | “Falmouth” ” ” 9 ” ”) |
| ” 3.— | “American” ” ” 4 ” ”) |
| ” 4.— | (From oyster-tank water after 13 days.) |

To these may be added the “Falmouth” oyster tank-water vibrio after 4 days. For this vibrio, although not differing from its parent in cultural and physiological respects, is, nevertheless, a markedly shorter and smaller vibrio than the St. Petersburg vibrio. It will be referred to as vibrio No. 5.

Time has not permitted of an equally exhaustive study of all these varieties, and I have had to limit myself for the present chiefly to vibrios Nos. 1, 3, and 4.

Flagella staining.—The different varieties of vibrio obtained, as above described, in one and another way, were subjected to the test of flagella staining. As Löffler first pointed out, the cholera vibrios from cultivations possess each a single spiral flagellum only, which is generally twice or thrice the length of the vibrio itself, and of the shape of a fine spirillum. It must, however, be added that although the vast majority of the cholera vibrios from cultures possess each a single spiral flagellum

* PLATE VI., fig. 6, page 141; PLATE X., fig. 23, page 145; PLATE XI., figs. 24 and 27, page 146; and PLATE XVI., fig. 46, page 151.

only, there are sometimes found here and there some individuals which possess at one and the same end two flagella, and occasionally, but rarely, even three spiral flagella. I am speaking of preparations made from surface agar cultures 16-24 hours old, and stained after Van Ermengem's silver method.

Now, comparing the above varieties of vibrios in respect of their flagella, by preparing the specimens all under the same conditions—from agar surface 16-24 hours old*—and staining them after Van Ermengem's method, it is found that all have the same kind of flagella. This is as a rule a single flagellum, of spiral shape, thin, and about two to three times the length of the vibrio.

Bordet-Durham test.—The above six (including the St. Petersburg microbe) samples of vibrios were next subjected to the Bordet-Durham test *in vitro*, with cholera serum.

This serum was obtained from a guinea-pig in the following manner:—A guinea-pig was injected for the first time, intraperitoneally, on March 2nd, with one-tenth of an agar culture (incubated 48 hours at 37° C.) of living cholera (St. Petersburg) vibrio. In the afternoon of the same day the animal was ill, but had fairly recovered next morning, and had quite recovered on the third day. It was injected again intraperitoneally on March 9th, this time receiving one-sixth of a recent agar culture, one-eighth of which produced death in a control guinea-pig in 20 hours. The experimental animal was distinctly ill in the evening, but next day had again recovered. On March 21st it received again, intraperitoneally, one-fifth of a recent agar culture, one-eighth of which proved fatal to a control guinea-pig in 20 hours. The experimental animal remained quite unaffected. Eighteen days from the last injection, the body weight having increased in the meantime, the animal was killed and its blood collected. With the serum thus obtained the test was made *in vitro*, with a bouillon distribution in each instance of samples of the six vibrios, the proportion being 10 per cent. of the serum in the emulsion thus made. The result was as follows:—In all cases, after two hours, the emulsion showed aggregation of the microbes, and a tendency of the clumps thus formed to settle at the bottom of the test tube, leaving a clear supernatant fluid.

This experiment was repeated next day with the same serum, with this result: fairly good reaction with the distribution in each instance of (a) the St. Petersburg cholera vibrio, (b) of vibrio No. 1, and (c) of tank-water vibrio No. 5; doubtful or negative reaction with vibrio No. 2, vibrio No. 3, and vibrio No. 4.

Pfeiffer's test.—With the same cholera serum as above, Pfeiffer's test *in corpore* was made as regards (a) the St. Petersburg vibrio, (b) vibrio No. 1, (c) vibrio No. 3, and (d) vibrio No. 5. Vibrio No. 2 and vibrio No. 4 could not be thus tested since no result is producible with them by peritoneal injection of guinea-pigs. In each case a recent (48 hours) agar culture was distributed in sterile bouillon, and of this emulsion a control guinea-pig received intraperitoneally the amount that was, from previous experiments, considered a fatal dose, while another guinea-pig received intraperitoneally a similar dose *plus* 0.5 cubic centimetres of the cholera serum. The result was as follows:—

(a.) *St. Petersburg vibrio.*—Control guinea-pig found dead next morning, *i.e.*, in 20 hours; "serum guinea-pig" lively and well.

* Incubated at 37° C. as regards the St. Petersburg vibrio, oyster vibrios, Nos. 1 and 3, and tank-water vibrio No. 5; at 20° C. as regards oyster vibrio No. 2 and tank-water vibrio No. 4.

- (b.) *Vibrio* No. 1.—Control guinea-pig lively; “serum guinea-pig” ill next morning, found dead on the third day.
- (c.) *Vibrio* No. 3.—Control guinea-pig found dead next morning, *i.e.*, in 20 hours; “serum guinea-pig” not affected at all, lively and well.
- (d.) *Vibrio* No. 5.—Control guinea-pig not affected and remained well; “serum guinea-pig” was quiet in the afternoon, but had quite recovered on the third day.

From this it appears that to Pfeiffer's test vibrio No. 3 responded in this experiment* just like the St. Petersburg vibrio. Now it will be remembered that this vibrio No. 3 differs from the parent vibrio (the St. Petersburg vibrio) in almost all morphological and cultural respects, as has been minutely described on former pages. It grows incomparably faster in plate and in stab culture; it makes the liquefied gelatine turbid; and it gives no cholera red reaction. So that, according to Pfeiffer's test, this vibrio No. 3 is, notwithstanding the above differences—permanent in character, as has been pointed out—the cholera vibrio. But, on the other hand, Pfeiffer's test, in that it gave negative result with vibrio No. 1 and with vibrio No. 5, would seem to imply that these are not cholera vibrios, notwithstanding that they are much more closely related, morphologically and culturally, than vibrio No. 3 to the St. Petersburg vibrio; and vibrio No. 5, which was obtained not from the oyster but from the tank water four days after St. Petersburg cholera culture had been added thereto, comes out particularly badly in this respect. It might, it is true, be urged that since the control animals in the case of vibrio No. 5 as also in that of vibrio No. 1 remained unaffected, the experiments go for nothing; yet the fact remains that the “serum guinea-pig” in one case (vibrio No. 5) was made ill and in the other (vibrio No. 1) died on the third day.

The above experiment was repeated later on with cholera serum obtained from the blood of a guinea-pig which had been immunised by repeated intraperitoneal injection of living cholera vibrio to such a degree that on the last (fourth) injection treble an otherwise fatal dose produced no result. The result was that the St. Petersburg vibrio and vibrio No. 3 gave positive, whereas vibrio No. 1 and vibrio No. 5 gave negative, response.

Now it will be remembered that vibrio No. 3 differed markedly from the parent, the St. Petersburg vibrio, as regarded its rapid liquefaction of gelatine, the strong turbidity of the gelatine liquefied by it, and the absence of cholera red reaction in its peptone culture; differing from that microbe in those respects more than No. 1 or No. 5. It will also be remembered that vibrio No. 5 (tank-water vibrio after four days) was in all essential cultural and experimental respects the St. Petersburg cholera vibrio, except that its commas were shorter than those of the latter grown under the same conditions; and that, nevertheless, it did not give Pfeiffer's test. I have pointed out in my last year's report that—as is quite established by Pfeiffer—if a particular vibrio does give Pfeiffer's test *in corpore* with cholera serum, it may be accepted as the true cholera vibrio. But I have also pointed out that there is no sufficient reason for supposing that cholera serum obtained by immunisation with one particular cholera vibrio must needs act germicidally on all other vibrios; upon, for instance, vibrios derived from other cases of cholera and differing amongst themselves in some morphological, cultural, or experimental respects. And I think that supposing a particular cholera

* Further experiments with a different cholera serum, made with this is passing through the Press, yielded different results.

vibrio has undergone some notable variation—as was the case with several of the vibrios now in question—such variation may very possibly entail essential biological and chemical changes and so render the modified vibrio not amenable any longer to the germicidal action of cholera serum obtained by means of different stock. If it be admitted—and I think no one who has practical experience of cholera bacteriological work will question it—that different varieties of cholera vibrios do exist, then it is not unreasonable to expect that these different varieties should behave differently towards a given cholera serum. If, therefore, Pfeiffer rejects as the true cholera vibrio those vibrios which do not give the positive test *in corpore* with cholera serum of a particular cholera stock, he is, I think, in error; a variation brought about by altered conditions may and does bring about profound changes in vibrios, and amongst these, as I believe, also a change in their behaviour towards cholera serum. At the same time I do admit that vibrios derived directly from cholera cases give, as a rule, the positive test. But even in this latter aspect the Massowah vibrio may be quoted as an exception; for this vibrio, which was derived from a cholera case, was by Pfeiffer himself used as “cholera vibrio” in his earlier experiments on “cholera poison,” was accepted and utilised for numerous experiments by Metschnikoff, but was nevertheless ultimately disclaimed by Pfeiffer as the true cholera vibrio because it did not respond to his test with cholera serum. It seems to me that in the case of Pfeiffer’s test, as in many other instances, though a positive result may help to establish and to prove the proposition, a negative result has much less value as a basis of inference.

OYSTER INQUIRY.

PLATE I.

FIG. 1.

Plate cultivation in *phenol-gelatine*, after incubation at 20° C. for three days, of typical *bacillus coli* obtained from an oyster.

[Natural size.]

PLATE I.

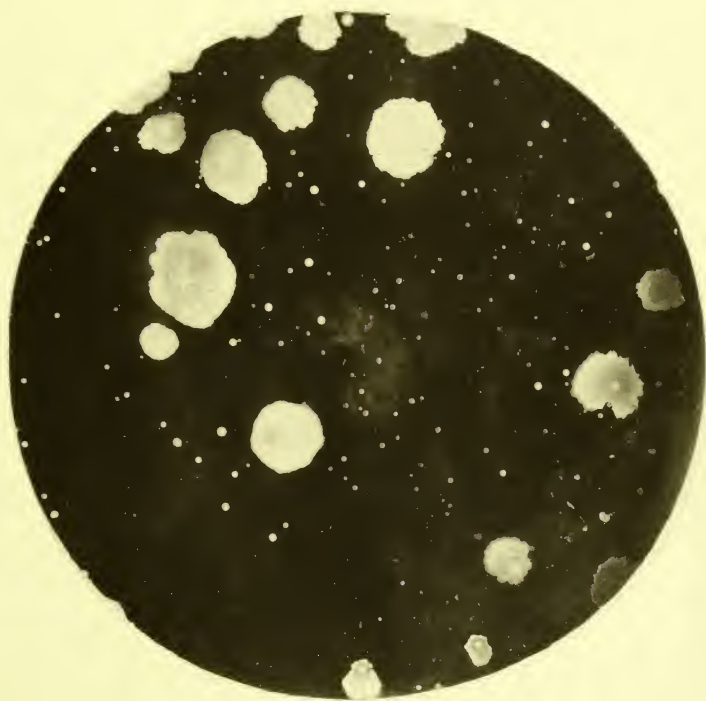


FIG. 1.

PLATE II.

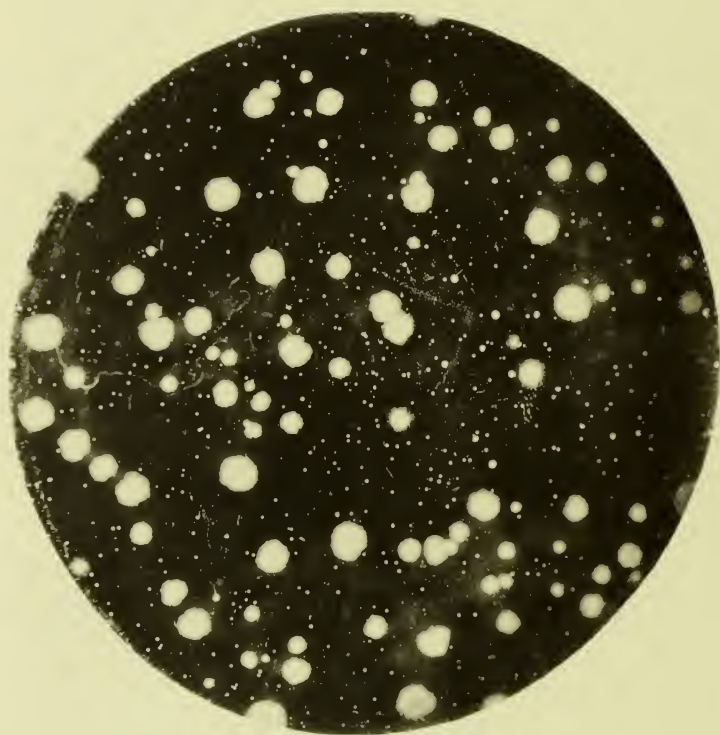


FIG. 2.

OYSTER INQUIRY.

PLATE II.

FIG. 2.

Plate cultivation in *phenol-gelatine*, after incubation at 20° C. for three days, of typical *typhoid bacillus* obtained from the interior of an oyster that had been kept for *nine* days in sea water to which culture of this bacillus had been added.

[Natural size.]

OYSTER INQUIRY.

PLATE III.

FIG. 3.

Plate cultivation in *gelatine*, after incubation at 20° C. for three days, of *Vibrio* No. 1 obtained from a "Falmouth deep-sea" oyster that had been kept for *four* days in sea water to which culture of Koch's cholera vibrio had been added.

[Natural size.]

PLATE III.

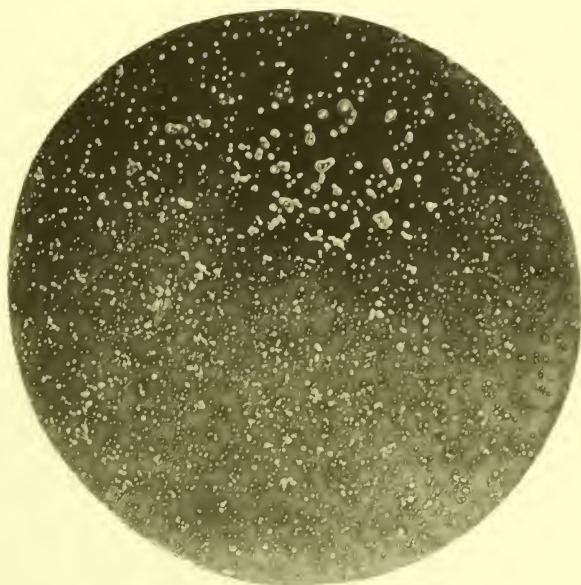


FIG. 3.

PLATE IV.

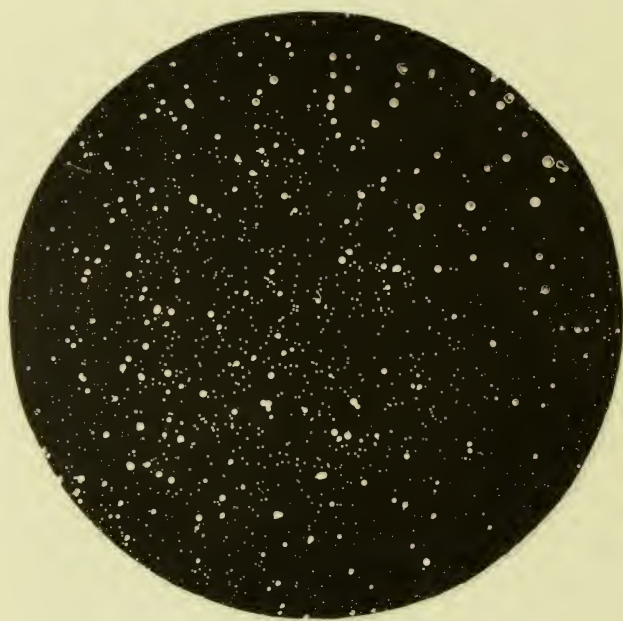


FIG. 4.

OYSTER INQUIRY.

PLATE IV.

FIG. 4.

Plate cultivation in *gelatine*, after incubation at 20° C. for three days, of *Vibrio* No. 5 obtained from sea water to which *four* days previously culture of Koch's cholera vibrio had been added.

[Natural size.]

OYSTER INQUIRY.

PLATE V.

. FIG. 5.

Plate cultivation in *gelatine*, after incubation at 20° C. for three days, of *Vibrio* No. 3 obtained from an east coast "American" oyster that had been kept for *four* days in sea water to which culture of Koch's cholera vibrio had been added.

[Natural size.]

PLATE V.

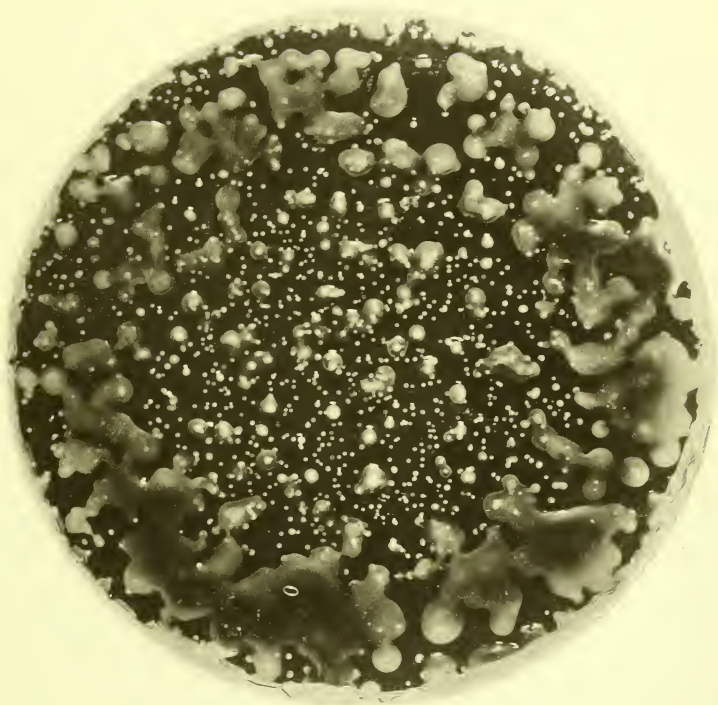


FIG. 5.

PLATE VI.

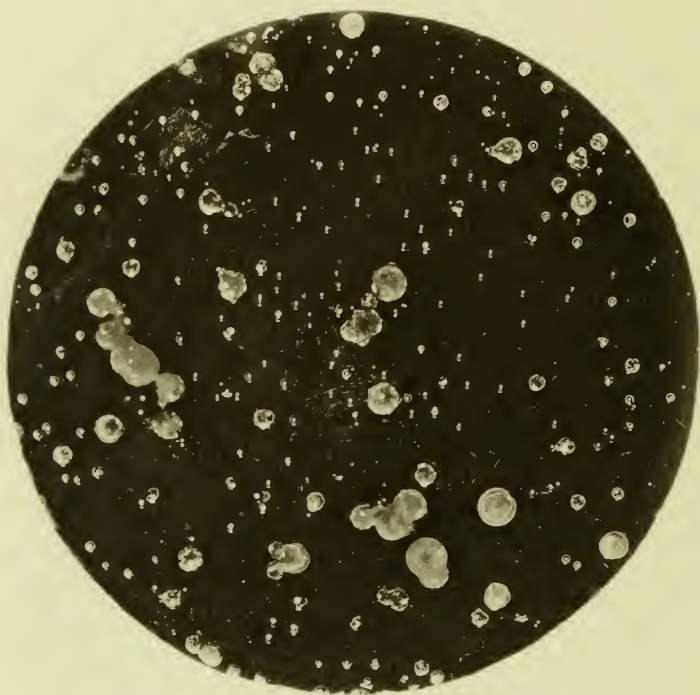


FIG. 6.

OYSTER INQUIRY.

PLATE VI.

FIG. 6.

Plate cultivation in *gelatine*, after incubation at 20° C. for three days, of *Vibrio* No. 4 obtained from sea water to which *thirteen* days previously culture of Koch's cholera vibrio had been added.

[Natural size.]

OYSTER INQUIRY.

PLATE VII.

FIG. 7.

Plate cultivation in *gelatine*, after incubation at 20° C. for three days,
of the *St. Petersburg vibrio*.

[Natural size.]

PLATE VII.

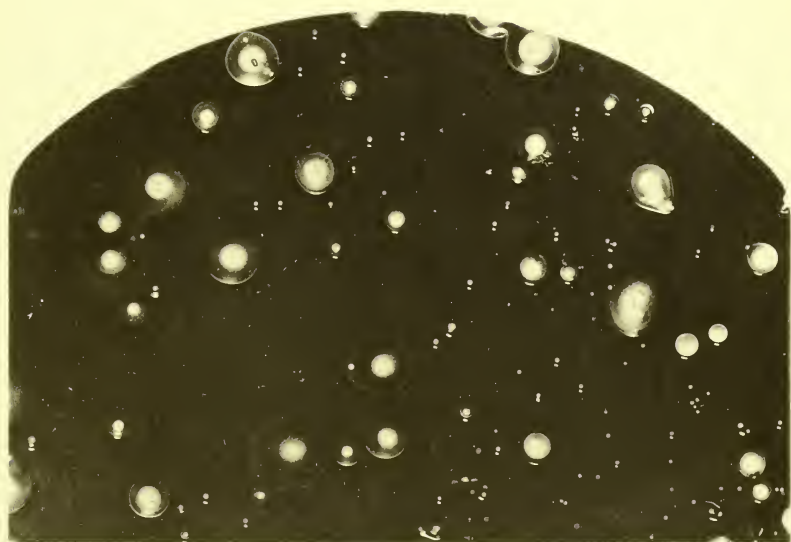


FIG. 7.

PLATE VIII.

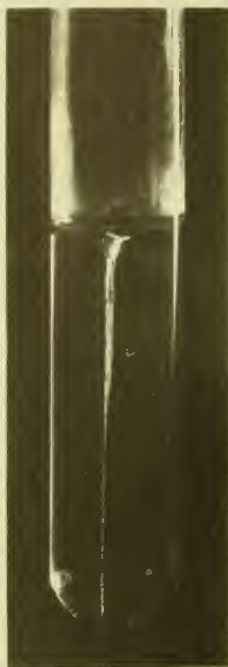


FIG. 8.



FIG. 9.



FIG. 10.

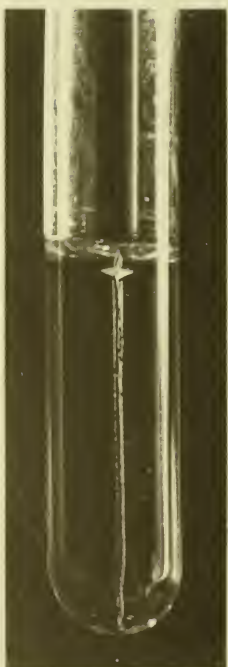


FIG. 11.



FIG. 12.



FIG. 13.

OYSTER INQUIRY.

PLATE VIII.

Showing Stab-culture in Gelatine of several *Vibrios*.

FIG. 8.

St. Petersburg vibrio, after incubation at 20° C. for *two* days.

FIG. 9.

St. Petersburg vibrio, after incubation at 20° C. for *seven* days.

FIG. 10.

Vibrio No. 1, after incubation at 20° C. for *two* days.

FIG. 11.

Vibrio No. 1, after incubation at 20° C. for *four* days.

FIG. 12.

Vibrio No. 1, after incubation at 20° C. for *eight* days.

FIG. 13.

Vibrio No. 1, after incubation at 20° C. for *twelve* days.

[Natural size.]

OYSTER INQUIRY.

PLATE IX.

Stab-culture in Gelatine of Vibrios—*continued*.

FIGS. 14, 15, 16, and 17.

Vibrio No. 1, at later stages of incubation than in Plate VIII.

FIG. 18.

Vibrio No. 3, after incubation at 20° C. for *twenty-four* hours.

FIG. 19.

Vibrio No. 3, after incubation at 20° C. for *forty-eight* hours.

[Natural size.]



FIG. 14.



FIG. 15.



FIG. 16.



FIG. 17.



FIG. 18.

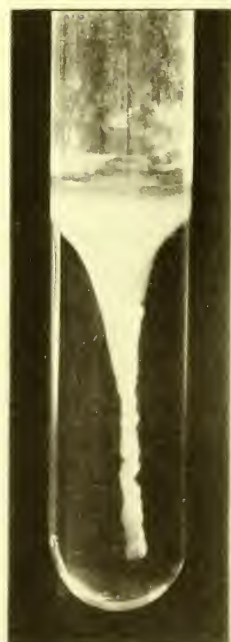


FIG. 19.

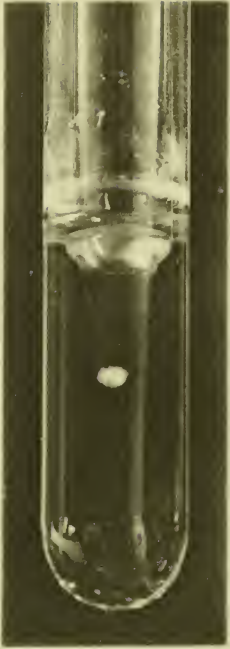


FIG. 20.



FIG. 21.



FIG. 22.



FIG. 23.

OYSTER INQUIRY.

PLATE X.

Stab-culture in Gelatine of Vibrios—*continued*.

FIG. 20.

Vibrio No. 2, after incubation at 20° C. for *seven* days.

FIG. 21.

Vibrio No. 2, after incubation at 20° C. for *two* days.

FIG. 22.

Vibrio No. 2, after incubation at 20° C. for *three* days.

FIG. 23.

Vibrio No. 4, after incubation at 20° C. for *seven* days.
[Natural size.]

OYSTER INQUIRY.

PLATE XI.

Stab-culture in Gelatine of Vibrios—*continued*.

FIG. 24.

Vibrio No. 4, after incubation at 20° C. for *four* days.

FIG. 25.

Vibrio No. 5, after incubation at 20° C. for *four* days.

FIG. 26.

Vibrio No. 5, after incubation at 20° C. for *eight* days.

FIG. 27.

Vibrio No. 4, after incubation at 20° C. for *ten* days.

[Natural size.]

PLATE XI.

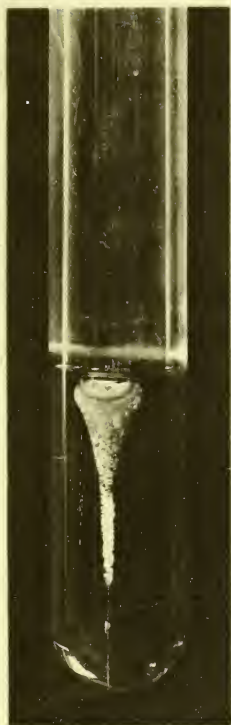


FIG. 24.



FIG. 25.



FIG. 26.



FIG. 27.

PLATE XII.

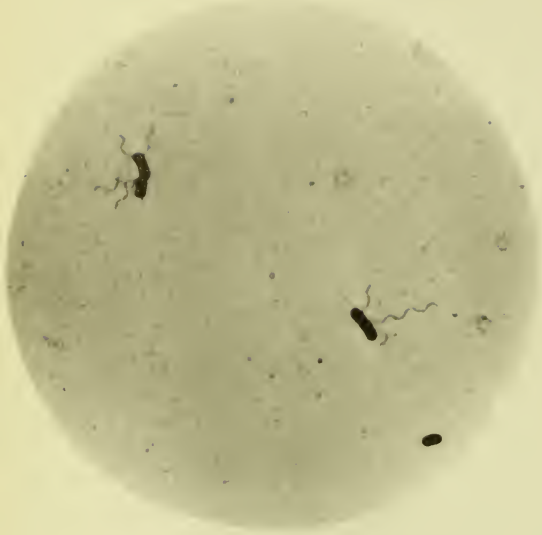


FIG. 28.

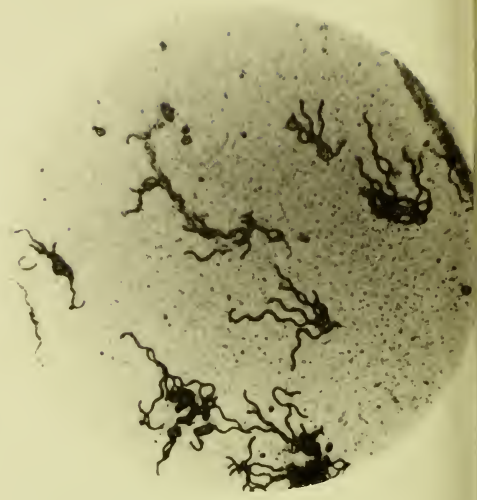


FIG. 29.

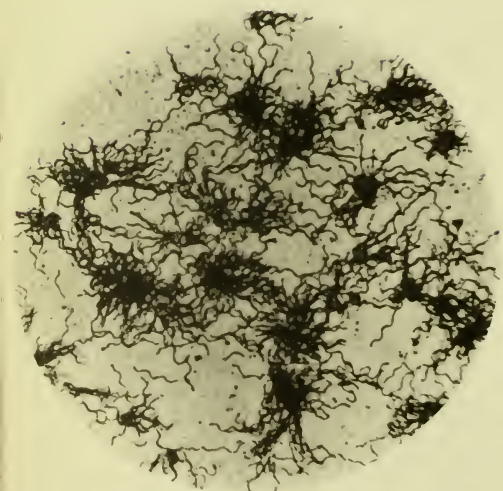


FIG. 30.

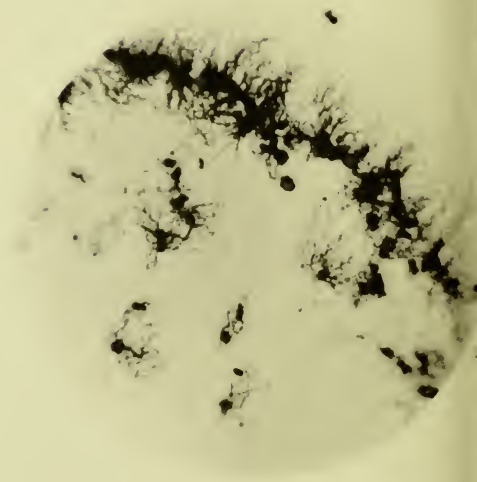


FIG. 31.

OYSTER INQUIRY.

PLATE XII.

Flagella Staining by Van Ermengem's Method.

Fig. 28.

Typical *bacillus coli*.

FIG. 29.

Variety of *bacillus coli*.

FIG. 30.

Typhoid bacilli obtained from an oyster that had been kept for *two* days in "typhoid-infected" sea water.

FIG. 31.

Typhoid bacilli obtained from an oyster that had been kept for *nine* days in "typhoid-infected" sea water.

[Magnifying power, 1,000.]

OYSTER INQUIRY.

PLATE XIII.

Flagella Staining by Van Ermengem's Method—*continued.*

FIG. 32.

Typhoid bacillus from an oyster that had been kept *sixteen* days in "typhoid-infected" sea water.

FIG. 33.

Typhoid bacilli from a fresh oyster examined immediately on its arrival from the sea coast.

FIG. 34.

St. Petersburg *cholera vibrio*.

FIG. 35.

Vibrio No. 1 from an oyster that had been kept for four days in "cholera-infected" sea water.

[Magnifying power, 1,000.]

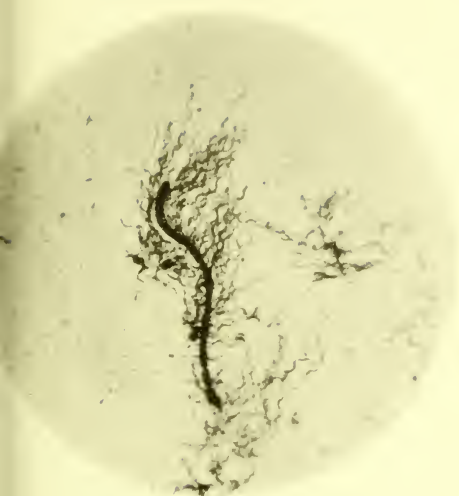


FIG. 32.

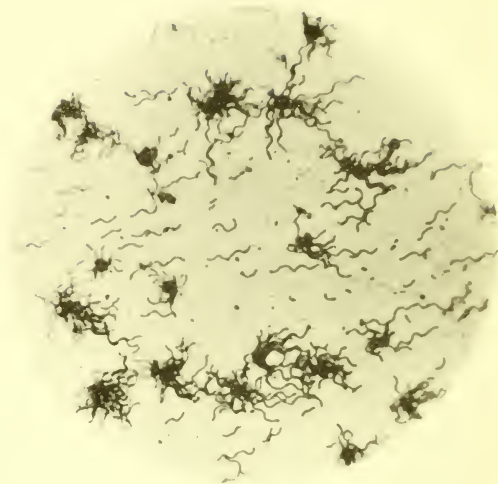


FIG. 33.

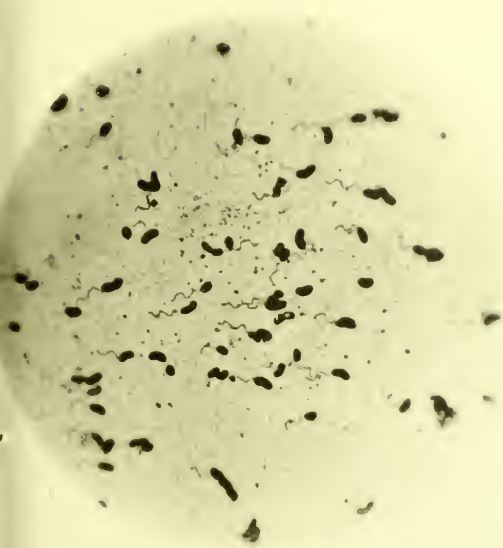


FIG. 34.

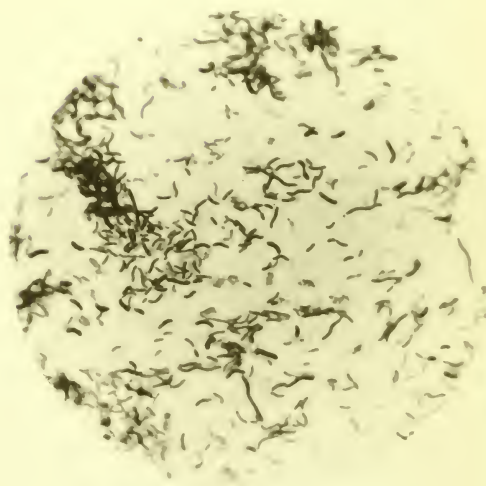


FIG. 35.

PLATE XIV.



FIG. 36.

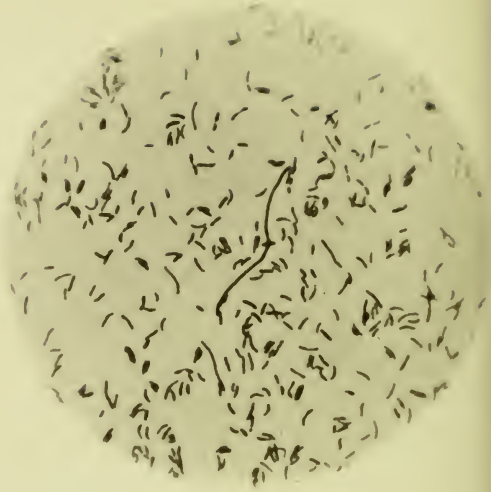


FIG. 37.

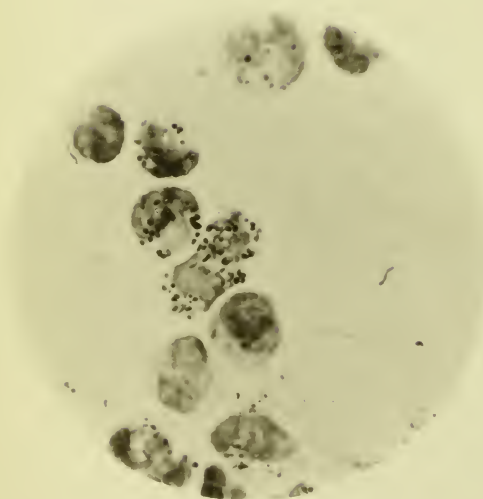


FIG. 38.



FIG. 39.

OYSTER INQUIRY.

PLATE XIV.

FIG. 36.

Film specimen of the *peritoneal exudation* of a guinea-pig, which died *twenty* hours after intraperitoneal injection with *Vibrio* No. 1.

FIG. 37.

Film specimen from a *peptone culture* of the peritoneal exudation in question.

FIG. 38.

Film specimen of the *peritoneal exudation* of a guinea-pig, which died *two* days after intraperitoneal injection with *Vibrio* No. 1.

FIG. 39.

Film specimen from a *gelatine culture* of *Vibrio* No. 2.

[Magnifying power, 1,000.]

OYSTER INQUIRY.

PLATE XV.

FIG. 40.

Film specimen from an *agar* culture of *Vibrio* No. 2.

FIG. 41.

Film specimen from a *peptone* culture of *Vibrio* No. 3.

FIG. 42.

Film specimen from an *agar* culture of *Vibrio* No. 3.

FIG. 43.

Film specimen of the *peritoneal exudation* of a guinea-pig, which died *twenty* hours after intraperitoneal injection with *Vibrio* No. 3.

[Magnifying power, 1,000.]

PLATE XV.



FIG. 40.

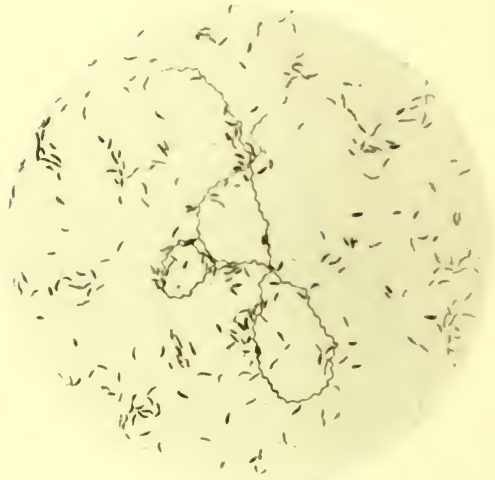


FIG. 41.

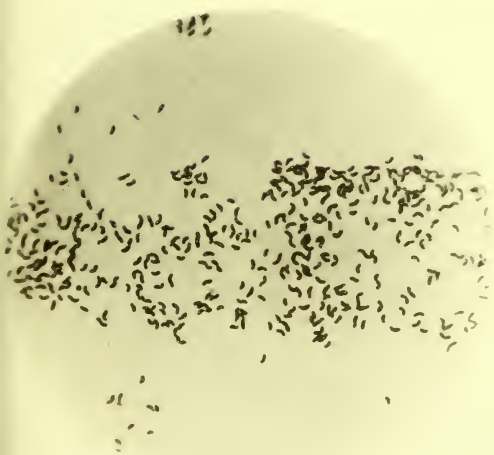


FIG. 42.



FIG. 43.

PLATE XVI.

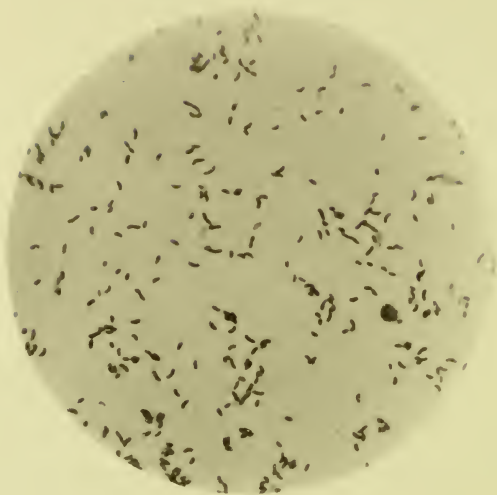


FIG. 44.

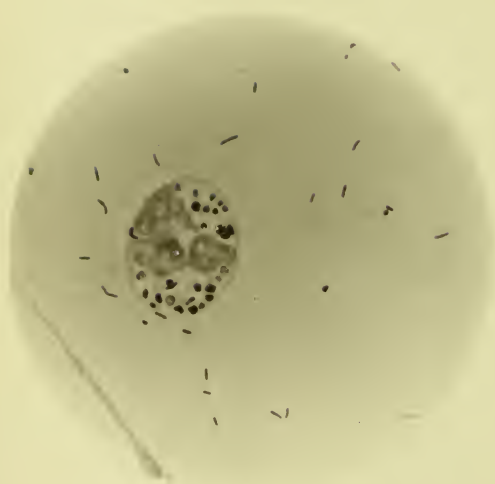


FIG. 45.



FIG. 46.

OYSTER INQUIRY.

PLATE XVI.

FIG. 44.

Film specimen of a *peptone* culture of *Vibrio* No. 5.

FIG. 45.

Film specimen of the *peritoneal exudation* of a guinea-pig, which died after intraperitoneal injection with *Vibrio* No. 5.

FIG. 46.

Film specimen of a *peptone* culture of *Vibrio* No. 4.

[Magnifying power, 1,000.]

APPENDIX No. 3.

COPY of a REPORT on an OUTBREAK of TYPHOID FEVER at WESLEYAN UNIVERSITY; by H. W. CONN, Professor of Biology.

(From the *Seventeenth Annual Report of the State Board of Health of the State of Connecticut.*)

The recent outbreak of typhoid fever at Wesleyan has been exceptionally unique in certain respects, and of a character that makes it especially interesting in the history of epidemics. A more typical example of an outbreak of typhoid, due to a single source of infection, has hardly been found in the history of medicine, and the example furnishes a demonstration of a new source of danger for this disease.

The use of raw oysters has before been suggested as a possible source of the spread of the disease. The readiness with which they absorb the water, and the fact that they not infrequently lie in positions where contamination with sewage appears to be possible, has led to their being suspected in several cases. It has hitherto, however, not been possible to trace any distinct epidemic to them with anything like demonstrative evidence. The conditions which have occurred at Wesleyan have, however, been exceptionally well adapted to point out this connexion. Indeed, if one had planned beforehand a series of experiments designed to prove the possibility of oysters as distributing typhoid, it would hardly have been possible to have devised a more satisfactory series of conditions than those which have attained in this outbreak at Wesleyan.

The history of the outbreak was as follows:—

About October 20th, several students in college were taken with a mild form of sickness, accompanied by a slight fever, which was not at first regarded as of much importance. The number of cases increased, however, and some of them became more severe, until after about a week it became very evident that some of the cases, at least, were those of typical typhoid fever. For a week and a half following October 20th, the cases increased rapidly, and by November 1st there were over 20 cases of sickness among students, accompanied by fever and with more or less typhoid symptoms. After November 1st the appearance of new cases declined, although one or two appeared on November 2nd, one case on November 5th, and one further case as late as November 9th. This limitation of dates is very important in the subsequent consideration of the epidemic. After the last date no more cases made their appearance.* In all there have been in college 25 cases of sickness

* One further case of fever it is necessary to mention. A member of one of the three fraternities was taken sick on December 16th with what proved to be a mild case of typhoid fever. This student had, however, been in college only a short time previously. During the excitement over the typhoid he had gone to his home and had remained there for a month. He had returned to college in December, but had not been back quite two weeks. It becomes impossible, therefore, to say whether this case is to be regarded as a case of secondary infection through the fraternity club house, or whether he contracted it at his home. His stay at home was too long to make it possible that he had contracted the disease before leaving college, and the period subsequent to his return before he showed signs of the disease was rather too short to make it very probable that he contracted it in his club, although long enough certainly to make this possible. It has been regarded as probable, therefore, that this case was contracted away from Middletown, although it is certainly not impossible that it was a case of secondary contagion contracted through the club house, where so many earlier cases had occurred.

which have been accompanied by fever. Of these, 23 have been pronounced by the physician in charge as typhoid fever, and 13 have been of a very severe character. There have occurred four deaths. Ten of the cases, although cases of fever and showing more or less typhoid symptoms, have been extremely mild, the fever continuing only a few days, and then disappearing without any serious results. One of these mild cases has been especially interesting. The student in question was taken with typhoid symptoms upon the 5th of November. In this case, however, although most of the typhoid symptoms, such as chill, headache, &c., were noticed, there was no fever. The student, however, was kept in bed for several days with the anticipation of the fever making its appearance, but no fever appeared, and recovery followed without any further trouble. It was learned that this student had suffered from a severe attack of typhoid some three years ago, and it is at least possible that the effect of the disease in the early years was such as to mitigate the symptoms at the present time, and prevent the run of fever which would otherwise have occurred. In general, the epidemic at Wesleyan must be regarded as of an ordinarily severe type. Out of 23 cases, four deaths makes a rather large per-centage, a fact which is partly accounted for from their being all young people. In some of the other cases the disease was extremely severe, although recovery finally ensued. At the same time there were some ten cases of very mild character.

As soon as it became evident that the disease in college was typhoid fever, the seriousness of the matter was at once recognised, and a committee consisting of Prof. J. H. Van Vleck, professor of mathematics, Prof. Wm. North Rice, professor of geology, and the author of this report, was appointed to investigate the trouble, to determine if possible the cause of the outbreak. This investigation did not begin until November 4th, for it was not until this date that the really serious aspect of the case was appreciated. At this date it was not known that the limit of the new cases had been reached, nor to what extent the numerous cases of slight illness would prove to be typhoid. At that time a few cases had been pronounced typhoid, the rest being simply suspicious.

At the very outset suspicion was thrown upon two wells on the college campus. These wells had been used by the students for years. The college buildings were supplied with city water, but some of the students preferred to drink from the wells, although they had been cautioned against their use. One of the wells was about 30 feet from the location of an old abandoned cesspool, and for this reason this well was naturally regarded at first with suspicion. A chemical analysis was immediately made of the two wells. One was found to be chemically good, but the other was found to contain an exceptional amount of albuminoid ammonia, the actual amount being six parts in a million. Although chemical examination alone gives little indication of the healthfulness of water, this amount of albuminoid ammonia was very large, and plainly indicated some undesirable contamination of the water. It is to be noted that the examination was made shortly after a heavy rain, which had followed a long drouth, and this may account for the exceptionally large amount of albuminoid ammonia. The use of the wells was, of course, immediately stopped on suspicion, but it appeared almost at once that the outbreak of the epidemic could not be attributed to the wells. In the first place many people in town were accustomed to drink of the wells as freely as the college students, and no outbreak of typhoid appeared among the townspeople. The wells

were on the back campus, close to the athletic field, and visitors to the games occurring in the fall used the water even more freely than the college students. These visitors, too, were mostly young people, just in the most susceptible age for taking typhoid. There was, however, no outbreak of typhoid in town at the time of the cases in college. Further, there had been no case of typhoid in college which could by any possible means have contaminated the wells in question for a great many years. The college is on the top of a high hill, so that no contamination from drainage of other houses was possible. Recognizing that typhoid infection usually comes from other cases of typhoid, it seemed hardly possible to trace the trouble to these wells, because of the lack of chance for contamination. Moreover, after questioning the students who were sick with typhoid, it appeared that several among them certainly had not drunk of the well that was contaminated, and some of them had not used any of the water from either wells. As a confirmatory test, however, a bacteriological study of the water was made according to the method of Dr. Vaughn. A sample of the water from each well was inoculated into bouillon, and allowed to grow in a culture oven at 35° C. for a couple of days. At the end of this time 20 drops of the culture were inoculated into the abdominal cavity of white rats. The white rats did not suffer in the least, as they certainly would have done had typhoid germs been present in the water originally. Moreover, the bacteriological examination showed that the wells, although contaminated with albuminoid ammonia, were somewhat exceptionally free from bacteria, which would grow in a culture oven. All these facts, of course, showed conclusively that the college wells could not be regarded as the cause of the outbreak. When it was found, further, as will be presently noticed, that the sickness was confined to the members of three societies among the students, while, of course, the use of the well water was not thus confined, it was necessary to abandon the well as a possible source of the typhoid.

At first there seemed to be no point of connexion between the students who were sick. Their rooms were in both of the college dormitories and in two fraternity club houses, while others roomed in private houses in town. These facts excluded the lodging-houses from suspicion. Nor did the students board at the same tables. Most of them boarded in fraternity clubs, but a few in private boarding places in town. One of the first points that was noticed after the investigation was begun was that the ladies among the college students, about 50 in number, were wholly exempt from the disease. This pointed to some source of contamination open to the gentlemen that was not open to the ladies, and at once ruled out any possible contamination through lack of sanitation in recitation rooms or round the college buildings in general. The first connexion between the cases, which served as a point of departure in the further investigations, was in regard to the fraternity relations of the patients. Among the gentlemen students there are seven college fraternities, which comprise in their membership most of the students. With three exceptions all of the cases of typhoid were found in three of these fraternities. These three exceptions will be noticed later, but the confinement of the cases within these narrow limits was certainly suggestive. It was especially so when the number of cases occurring in three fraternities was considered. It was very evident that in these three fraternities there was some extremely potent source of typhoid infection. The members of the three fraternities comprised about 100 students, and among them, at least 23 have been sick with typhoid fever of more or less severe symptoms. This is an

exceptionally large per cent., and anything which could produce such a large proportion as this must have been an universal source of contamination to all the members of the society and not a purely incidental one. The presence of such a large per-centage of cases among three fraternities plainly showed that it was necessary to look for the cause in these fraternities, in spite of the three seemingly exceptional cases. It indicated, moreover, that the source of the typhoid could not be an incidental one, in which the chance of contagion was slight, but an extremely prolific source to which practically all of the members of the fraternities were exposed. All conceivable sources of contamination were, however, investigated, and in the following pages the investigations are given in some detail, in order that it may be seen that the search was a thorough one, and not a hasty decision that the oysters were to blame.

One of the first points to be considered was the plumbing of the fraternity club houses. It was hardly to be expected, however, that this could be the source. The three houses were at a distance of about half a mile from each other, and were connected with at least two different sewers. There was at the time very little typhoid fever in town to contaminate the sewage. In two of the houses some of the students lodged, but in the third none of the students roomed, the house being used simply as a club house. Considering all of these facts, it is absolutely incredible that these three houses should *simultaneously* have such defects in their plumbing as to produce nearly 25 cases of typhoid within two weeks. An examination of the plumbing showed it to be in good condition. Two of the houses were new and fitted with the best of modern plumbing, and there was no reason for suspecting any defect in the third house. The lack of typhoid in the city, the connexion of the houses with different sewers, the large per-centage of cases among the members of the fraternities, and the simultaneous appearance of the disease in three houses, altogether ruled out the plumbing as a possible source of infection.

After thus excluding the plumbing the next attempt was made to trace the infection to the tables of the fraternity clubs. Most of the members of the fraternities boarded at these clubs, and the few who did not board there regularly, occasionally took meals at the clubs. An examination was therefore made into the sources of supplies of the three clubs. But the result of the researches in this line were not promising.

Water.—The three fraternities used at their tables the ordinary city water from the city reservoir, and this, of course, at once exempted water from the possible sources of infection, inasmuch as there was at the time scarcely any typhoid fever in the city. While it might be claimed that the city water was a possible source of typhoid, no one could believe that its effects could have been confined to members of three college fraternities and produce there 25 cases.

Ice.—The use of ice in ice-water was in a similar way exempted. The same source of ice which was used by the three fraternities in question, was used by all the other college fraternities, and by the townspeople generally.

Milk.—The question of the milk supply was among the first to be considered, inasmuch as milk has so frequently been known to be the cause of typhoid outbreaks. But careful examination showed that this could not be the cause. The three fraternities were supplied by two different milkmen, whose farms were several miles from each other, and who had not exchanged milk with each other in any way, such as to

give a common source of milk to the three fraternities. Moreover, each of these milkmen supplied one or more of the other college fraternities, which were exempt from typhoid, and each of them had a large patronage in town. This, of course, made it impossible to believe that their general milk supply could be a source of typhoid. Each of these milkmen furnished all of his milk from his own farm with an occasional exception. Occasionally each would borrow milk from other sources, but always at the end of his daily route while the club houses were at the beginning of the route. No typhoid fever had occurred, either on or in the vicinity of either of these milk farms within six months, nor was it possible to trace any of the cows to an infected locality. These facts, together with the lack of any typhoid fever among the other patrons of these milkmen, excluded the milk as the source of infection.

Ice-cream.—The clubs occasionally had ice cream, but had obtained it from different sources, and inquiry showed that the cream from which it was made came from widely separated dairy farms. The cream was also widely used in town.

Miscellaneous.—No better results came from the examination of the other articles of food used in the clubs. The three clubs patronised different meat men and different grocers. Their butter was derived from various places and the same was true of their fruit. The same dealers in groceries, meat, butter, and fruits and fish, which supplied these three fraternities, also supplied the other fraternities in college and many people in town. The attempt was also made to determine whether any special lot of food had been used by the fraternities in question which could possibly have been a single source of infection, but no such article of food was found which had been used by these three fraternities. Various different articles were suggested by the one fraternity or the other as perhaps open to suspicion. One mentioned a lot of bad ham, another a lot of canned fruit. But investigation showed that these particular articles of food were not used in common by the three fraternities in question, or that they were used equally by the fraternities that had been exempt from trouble.

A suggestion was made early that a lot of new football suits that had been purchased for the football team might have been the source of original infection there having been some reason for suspecting that certain slight cases of blood poisoning had arisen from these suits. The possibility of contamination of these suits with typhoid material was recognised. It is, of course, possible that they may have been made in families where there was a case of typhoid, and have thus become contaminated by infectious material. The chance is doubtless very slight, but it was at all events worth inquiry. The inquiry, however, was futile. Only a few of the men who had used the suits had suffered from typhoid, while several of the sick men had never touched them. Nor could these suits have furnished any connexion with the three societies in question, since they were used equally by members of all the college fraternities.

An attempt was made to connect the three societies together by the room-mates of the students who had suffered from the disease, but this proved also futile. Most of the students roomed with members of their own fraternity, and in many cases the room-mates of those that were sick had not suffered from the disease at all. No case of contagion from patient to patient has occurred in the whole epidemic. There was found to be no common connexion between the three fraternities by means of their room-mates, and this line of investigation was abandoned. It was learned that at the first of the disease no special precaution had

been taken in the fraternities in regard to the dishes that were used by the members that were sick, and a possible chance of distribution of the disease from the individual through the fraternity table was thus suggested. But against that theory arose the fact that all of the cases developed within two weeks of other. If they had come from one or two original cases, and been thus transported through the dishes at the tables, no such close aggregation of the cases together would have been found. Indeed, upon inquiry, it was found that there were *no early cases of fever* which could have served as the source of others. The first case appeared about October 20th, and within a week from that time at least 15 other cases had made their appearance. These facts, of course, indicated plainly a common source of infection and made it impossible to believe that any first case was the source of the others. Its simultaneous appearance in three societies made it impossible to explain the outbreak by contamination from first cases through carelessness at the eating tables.

The attempt was then made to determine the location of all typhoid cases in the city, to find out if a possible connexion of the three houses with any of these cases could be found. This again proved impossible. An interview with all the city physicians showed a remarkably small number of cases in the city for this time of the year. None of them were in any way related to the three clubs, nor in position to make contamination from them possible. The only imaginable method by which such cases could have produced the violent outbreak in the clubs is by infecting the food or drink of the clubs. No such possible infection could be found, for none of the patients had any connexion, either direct or indirect, with the college or club supplies.

In short, all the lines of investigation upon the relations of the students, the conditions of their fraternity houses, and the tables at the fraternity houses led to negative results, giving no point of common union between the three fraternities in question, which was not shared equally by the four other fraternities and the ladies in college, and equally by the citizens in town.

As soon as it was seen that the ordinary table of the fraternities was not likely to give the cause of the trouble it became necessary to look elsewhere. When the dates above mentioned as the limitations of the outbreaks are considered they are found to be very suggestive. All cases occurred between the 20th of October and the 9th of November. The period of incubation for typhoid is not exactly known, but it is from about eight to 28 days, varying widely, and sometimes even slightly exceeding these two limits. When, therefore, it was learned that all of the cases appeared within two weeks of each other, it became evident at once that there ought to be found one *single* common source of infection in these three fraternities occurring within two weeks previous to the first case. These dates at once threw into suspicion a series of fraternity suppers held at the society initiations upon the 12th of October. The date of these suppers, October 12th, it will be noticed, is just exactly the proper date to explain the outbreak of typhoid on the 20th of October, and its disappearance after the fourth week following the suppers, about November 10th. Indeed these dates in themselves are almost sufficient to demonstrate these initiation suppers as the source of infection. It was now seen, too, that by taking into consideration the initiation suppers, was found an explanation of one of the three cases which had appeared among members of the college not in any of the three fraternities. One of the members of the college who had suffered from the typhoid had attended the initiation banquet held

by one of these three clubs, but had not boarded with the clubs either before or subsequently.

The menu of the suppers on these initiation nights was at once carefully examined in the various college fraternities. It was found that nearly everything used at the initiation suppers was exempted as a possible source of infection, in the same way that the articles of food on their ordinary tables were exempted. The water, the ice, and the milk and cream came from the same sources from which they were derived in subsequent weeks, and as we have seen, none of them could have possibly been the cause of the trouble. The ice-cream which was used in the three fraternities was obtained from two different sources, and the cream from which the ice-cream was made was also obtained from two different dealers living a long distance from each other. Moreover, the cream from each of these farms had supplied other fraternities, and had been used constantly during the fall by people in town without producing any trouble elsewhere. Fruit was regarded as a possible source, since it is eaten uncooked. But inquiry showed that the fruit must be exempted, because the source of fruit in the fraternities in question was the same as that of the other fraternities not suffering, and the same as that of a large number of people in town. Each of the three fraternities had salad on their tables, chicken salad in one case, and lobster salad in the others. Neither the chicken nor the lobster could be blamed, since they were derived by the three fraternities from three different sources. The celery used in the salad was regarded as a source of possible danger. The celery was purchased from different dealers, but these dealers obtained it all from the same man. This man produced the celery on a farm in Cromwell. During the fall he occasionally washed his celery in the water of the Connecticut river, his own well being dry at the time. This was at first regarded as suspicious. But further inquiry showed that the same dealer furnished nearly all the celery that is used in the city, and had consequently furnished hundreds of families from the same source. While, then, it is possible that the celery contaminated by the river water might have been the cause of an occasional case of typhoid, it was impossible that it could have caused the excessive large proportion of cases which had occurred as the result of the initiation suppers. It could not have localised itself in the participants of these three suppers without producing corresponding epidemic in the city.

After going through the entire bill of fare at these suppers, tracing up the origin of every article of food or drink, there were found to be only three other articles of food in common at the three. These were ham, derived from the same dealer, a small amount of fruit, and oysters from the same fish dealer. The ham was of necessity excluded, for two reasons. First, it was cooked before it was eaten; and secondly, the same dealer furnished other fraternities with ham. Add to this the difficulty of understanding how the ham would have been contaminated, and it was evident that the blame could not be placed here. The fruit was equally used by other fraternities and by townspeople, and was therefore of necessity excluded.

As soon as attention was turned to the oysters, however, the problems began to be solved at once. To those engaged in the investigation, one of the most striking phenomena was the quickness with which the puzzling questions were answered as soon as they were studied in the light of the oysters as a possible source of contamination. It was found that the ladies in the college did not hold any special supper on the evening of October 12th, nor eat raw oysters either then

or subsequently. It was found that of the other four fraternities, two did not use oysters at all at the initiation suppers; one obtained oysters from Hartford dealers, who obtained them from a different source than the Middletown dealers. The fourth used the oysters from the same source as the fraternities in question, only had used them cooked, while the three fraternities that had suffered from typhoid had eaten the oysters on the half shell and, consequently, raw. As soon as it was conceived that the oysters might be the cause of the trouble, one more of the exceptions above mentioned was explained, for one of the students belonging to another fraternity, who had suffered from a mild fever, stated that at about the time of the initiation banquets, he had eaten raw oysters in the oyster dealer's store in town. This, of course, made it possible to bring this case within the same source of infection. Inquiry as to the use of the oysters in town revealed nothing which relieved the oysters of blame. Quite a number of families were supplied from the same lot of oysters, but so far as could be learned only one family bought them to eat raw, and this family has subsequently moved from town and has been lost track of. Further facts concerning this case will be mentioned later. The attendants in the oyster dealer's store had probably eaten of the raw oysters, inasmuch as they did frequently do so, although they had no definite recollection of this particular lot. Neither of them had experienced any evil results. This, of course, is not surprising since ordinarily not much more than 10 per cent. of those exposed to typhoid suffer from the exposure, and even among the students at the banquet not quite one in four took the disease. If the people in town who ate the oysters had not generally cooked them before eating them, a larger number of cases would have been expected.

The oysters at these suppers were served on the half shell as a single course at the beginning of the supper. It was, therefore, extremely probable that all persons who attended the banquets ate of them, except such as had special dislike of oysters. In order to be certain of this, however, inquiries were made, where it was possible, of the students who were sick, and letters of inquiry were sent to all who had gone away. From the replies to those inquiries it has been possible to trace direct connexion with the oysters in all cases except one. One student does not remember having eaten the oysters. He did, however, attend one of the three banquets, though he ate little, being unwell at the time. Up to the present time this student has been too ill to be personally questioned, and his presence at the banquet where the oysters were served certainly gives at least an indirect connexion with the oysters, even if his memory should not later disclose a closer connexion. It has been ascertained that the four young men who have died did eat of the oysters at the suppers in question.

It was learned that at these same suppers were quite a number of persons who were not students of the college. Some of these were a number of alumni of the college and five students from Yale. Letters were at once sent to these persons to determine whether they ate of the oysters, and whether they had suffered from any sort of fever since that time. It was not expected that there would be such a large proportion of cases among the alumni, inasmuch as they are older men, and typhoid is especially apt to attack young people. Reports have been received from twenty-four of the alumni who ate of the oysters. Among them have been found several cases of slight illness, chills, diarrhœa, weakness, &c., which appeared at about the same time that the cases of typhoid appeared in Middletown. These may or may not have had some connexion with the infection. But there have been found four cases of genuine typhoid fever, most of which had been diagnosed as typhoid

before there was knowledge of the connexion with Wesleyan cases. None of the cases had been severe, but all appeared simultaneously with those in college.

Of the five Yale students who attended the banquet, two developed typhoid fever. These two cases appeared quite late, developing the second week in November. The date of their appearance was just about four weeks after the suppers, and at just about the same time that the last case appeared at Wesleyan. There were two other cases of typhoid at Yale, which were certainly not traceable to the suppers nor to eating oysters. This, of course, indicates that there is some other source of infection at that place, and possibly these two students who attended the suppers at Wesleyan may have received their infection elsewhere. It is, however, a very remarkable coincidence that of the four cases at Yale, two should have been those in attendance upon these suppers, and that both cases should have developed within the known period of incubation of the disease after the initiation suppers. While not certain, therefore, it is extremely probable that these cases were due to the same source as the outbreak at Wesleyan.

These last facts, of course, proved to practical demonstration that the cause of the infection was to be looked for in the initiation suppers. The cessation of the cases at the end of four weeks, the appearance of at least six cases among the visitors who came to the banquets, and went away immediately without having anything else to do with the college, are sufficient in themselves to indicate beyond peradventure that the initiation suppers are to be regarded as the source of infection. And when, further, it is seen that only one article of food or drink was used in common by these three societies, that was not used equally by the other fraternities in college and by people in town in general, it becomes equally certain that this one article of food must have been the source of infection.

It will be seen that after the blame has been placed on the oysters all of the exceptional cases were explained except one. This one still remains an exception. One member of the faculty had an attack of fever at about the same time as the other students. He had not attended any of the banquets. Whether this was a case of typhoid fever is at least doubtful. The fever was slight and only lasted a few days, disappearing without leaving any evil results. Appearing with the other cases it was naturally regarded as of the same nature, but it would not have been considered as typhoid if it had occurred as an isolated case. Whether this person ate of the raw oysters it has been impossible to determine. Raw oysters were served at his boarding-house at about the time of the banquet but whether he ate of them is uncertain. It seems more probable that this case was an isolated case of fever having no connexion with the others.

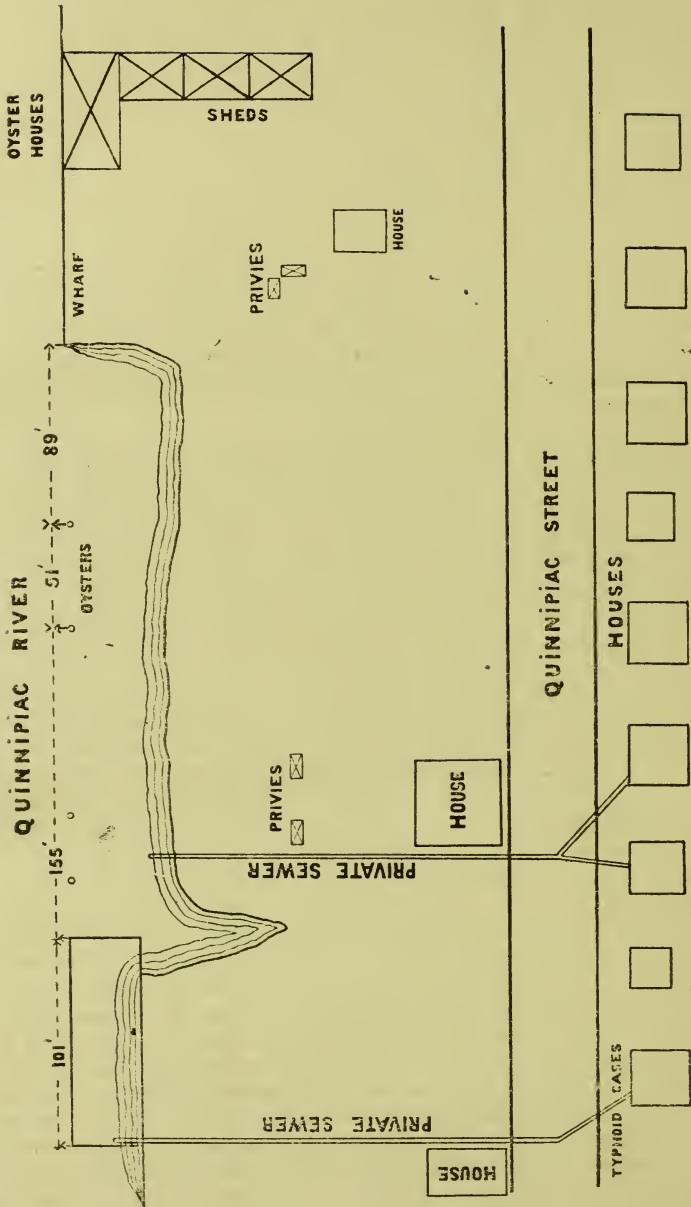
As soon as these facts became clear the source of the oysters in question was investigated. These oysters were obtained from Fair Haven, Conn. It should be stated that the dealers who furnished these oysters have aided in the inquiry and given all the information possible. They have been perfectly frank in their dealings and have aided the investigation even to the injury of their business. Nothing but commendation should be given them, for no blame attaches to them, and the error in fattening the oysters was corrected as soon as its evils were understood. Inquiry showed that the oysters in question had been taken from deeper water in Long Island Sound and had been brought into the mouth of a creek known as Quinnipiac River, and allowed to lie in fresh or brackish water a day or two for fattening before they were taken out of the water and

sent to the consumers. During this period of fattening the oysters are known to absorb freshwater and to swell up and become quite plump. The object of this treatment is partly to thus "fatten" the oysters and partly to wash them. Close to the oyster beds where this fattening occurs are the outlets of a number of private sewers. At a distance of some 300 feet from the beds where the oysters were fattened was an outlet from a private sewer from a house in which were two cases of typhoid fever. The patients were a lady and her daughter. The cases were severe, the lady dying on the 21st of October, and the daughter convalescing only after five weeks' sickness. The accompanying diagram shows the exact relations of these localities. The oysters were placed to freshen at the place marked "oysters" between two stakes. The outlet of the sewer is shown at the bank of the river under the lower end of the wharf, and the distance from the outlet to the oyster ground is, as shown by the diagram, between 250 and 300 feet. When the grounds were surveyed it was further noticed that at the rising tide an eddy was found to be setting along the shore from the region of the sewer outlet up stream, in the direction of the oyster beds. This condition would plainly make it possible for typhoid contaminations from the sewer to be carried to the oysters.

Examination as to the dates of the cases of typhoid occurring in the house on the sewer showed that the two persons in question were taken sick at just about the time that the oysters sent to Middletown were collected. The oysters were sent to Middletown on October 10th, and the doctor was first called to these cases on October 11th. The period of incubation of typhoid fever is known to be somewhat variable and had certainly existed some time before the doctor was called. From the fact that when the doctor was called the lady was suffering from a severe chill and fever, it was plain that the conditions were such that infection through the sewer might naturally have taken place at least for several days prior to the period of the first visit of the doctor; for during this incubation period the persons may appear well and yet the presence of the typhoid germs render their excreta infectious. Indeed, the danger might be even greater at this stage than subsequently, since as soon as the disease is plainly indicated nurses will be pretty sure to disinfect the excreta and thus diminish the danger. This would bring the time of possibility of infection at just about the period when the oysters sent to Middletown were collected.

The question arose at once whether the typhoid germs would live under the conditions presented in these oysters or be killed by the salt water or the oyster juices. That the germ is not killed by salt water has been shown by both Freytag and Foster, both of whom have found that the typhoid organism will live for weeks in a concentrated salt solution. Specimens of the oysters were, however, submitted to Dr. Charles J. Foote, of the Yale Medical School, for testing the question directly. The report of this work will appear elsewhere, but the general result was to show that the typhoid organism will live in the oysters long enough to have the oysters taken to Middletown and be eaten. In these experiments the bacilli typhi abdominalis were forced in between the shells of the oysters from the creek and were found alive and capable of growth at the end of 48 hours. This is all that is required to account for the outbreak at Middletown.

The conditions under which these oysters were obtained is evidently the ideal condition for the contamination of the oyster by the typhoid infection. The oysters certainly absorbed freshwater while lying on this creek. Whether they do this on rising or on falling tide is a matter of no special importance, for if the water becomes contaminated with



the typhoid germs and the sewage, the rising as well as the falling tide would serve as a source of infection. The tide does not rush in and out with one steady sweep, but currents and eddies run hither and thither at all times. As already noticed some of these currents run in the proper direction to carry the sewage towards the oysters on rising tide. It is not to be expected, however, that all of the oysters in question would be similarly infected. Some of them might perhaps be entirely free from infection of typhoid germs while others would be quite badly contaminated. This would depend upon whether a current chanced at the right moment to carry typhoid material to the oysters. It would not be surprising, therefore, to have certain lots of the oysters give rise to a large number of cases of typhoid while others from the same bed, taken at perhaps a different tide, when the currents and eddies were slightly different, might have produced no such effect. The extent of the danger it is very difficult to determine. It would depend upon the closeness of the sewer, the direction of the eddies and currents, and especially upon whether the germs would multiply in the oysters or simply remain alive there. If they actually multiply the dangers would, of course, be much increased. The results of Dr. Foote's investigations into this matter are therefore of special importance.

It would be, of course, extremely interesting to follow up the oysters obtained from these localities and to determine whether elsewhere the same oysters have produced typhoid fever. This is extremely difficult to do. In the first place most of the oysters which are used by the public in general are cooked before they are eaten, and cooking destroys the typhoid germs with the greatest readiness. It is not to be expected, therefore, that the oysters would generally produce the trouble. Again, it is known that only about 10 or 12 per cent. of persons exposed to typhoid fever take the disease. The per-centage of cases in college was exceptionally large, because all of those eating of the oysters were of the age most susceptible to this disease, but the same oysters used elsewhere would be used by people miscellaneously, and it would be, of course, difficult to note very positively the evidence of typhoid as produced by the oysters. The exceptional conditions occurring at Wesleyan of a large number of young persons eating of the oysters at one time had made it possible to trace the connexion in this case. But when the oysters are scattered, as they are in ordinary trade, they are generally cooked before being eaten, and when we remember that only a small per cent. of cases of persons exposed take the disease, it is evident that it is impossible without very extended investigation to trace the connexion elsewhere. At Amherst College, however, conditions have occurred quite similar to those at Wesleyan. At the same time that the typhoid appeared in Wesleyan a few cases of the disease developed at Amherst. After the epidemic at Wesleyan had been traced to the oysters, it was learned from the dealers that the Fair Haven oysters had also been sent to Amherst. Letters of inquiry were consequently sent to President Gates, suggesting that possibly the Amherst students were suffering from the same cause as those at Wesleyan. Inquiry on the part of the President resulted in showing the following facts: There have been seven students at Amherst who contracted typhoid, one of them contracted it at his home, most all of the others were members of a single fraternity. These students did not room together nor all board together. It was learned, however, that their fraternity did hold an initiation supper upon the evening of October 12th, the same date as that of the Wesleyan suppers, and were served with raw oysters, all but one of those sick ate raw oysters on or

about October 12th. Inquiry showed that the oysters came from Fair Haven, although it has not been learned whether from the same dealer who supplied Wesleyan or not. The conditions, it will be seen, were almost identical with those at Wesleyan, and while it is hardly justifiable, without further evidence, to assume that the Amherst typhoid was due to the same lot of oysters, the coincidence in dates and in condition render it extremely probable.

A final piece of evidence confirming in a striking manner the view that the oysters were to blame has been recently obtained. It was learned that a young man in Boston who had been suffering from an extremely severe case of typhoid fever had visited Middletown at about the date of the banquets. Inquiry revealed the fact that he was taken with the disease simultaneously with the Wesleyan students, and that he had eaten raw oysters while in Middletown. It further appeared that the oysters which he ate were from the same lot as those which supplied the Wesleyan banquets, and that he had in fact partaken of the one lot, which, as mentioned on a previous page, had been sold by the Middletown dealer to be eaten raw. This is plainly a striking confirmation of the fact that the lot of oysters sent to Middletown was exceptionally infected.

It may be well to summarise the chain of evidence which leads to the conviction of the oysters as the cause of the Wesleyan epidemic.

1. The dates of the cases appearing at Wesleyan, all between October 20th and November 9th, plainly point to a single source of infection to which all the afflicted students were exposed at about the same time. This must have occurred a little more than a week earlier than the appearance of the first case, and the initiation suppers perfectly fill the conditions.

2. That these initiation suppers were the source of infection is rendered certain from the fact that four of the visitors who attended these banquets and have had no further connexion with the fraternities, have developed typhoid simultaneously with the cases in college, and by the further fact that two visiting Yale students who attended the suppers have similarly suffered from typhoid.

3. The fact that only three out of seven fraternities holding suppers on that evening suffered from typhoid, pointed to some article of food or drink used at these three suppers and not used in the other fraternities.

4. The fact that about 25 per cent. of the students attending the suppers have suffered from typhoid pointed to a universal and very active source of infection, and not to an incidental one. Whatever article of food contained the infectious material must have been eaten by nearly everyone present to account for such a large per-centage of cases.

5. Only one article of food or drink was used by the three societies which was not used equally by the other four fraternities. This article of food was oysters and they were eaten raw.

6. These oysters came from a creek, where they had been allowed to fatten for a day or more, within 300 feet of the outlet of a private sewer, and in such a position as to make contamination from the sewer a possibility. At the time that the oysters were there deposited there were two persons in the house supplying the sewer who were in the incubation period of typhoid fever, the period during which no attention would be paid to their excreta.

7. Typhoid germs are not injured by sea water or oyster juices, and if they found their way into the oyster would certainly have lived long enough to be sent to Middletown and be served on the tables of the fraternities.

8. Twenty-three cases of typhoid fever followed among the students in attendance on the suppers at which the oysters were eaten, and six cases among persons in attendance and not among the present students at Wesleyan. In all of the cases of undoubted typhoid it has been possible to trace either direct or indirect connexion with these oysters. The oysters were also eaten raw by one family in town, and at least one severe case of typhoid followed.

9. The use of oysters from the same locality by the students at Amherst College produced, or at all events was followed by an outbreak of typhoid fever among the students who ate of them.

These facts, taken together, form a chain of evidence practically complete at every point and leaving no room for doubt. Whatever may be said in regard to oysters in general, the Wesleyan outbreak of typhoid was caused by a special lot of contaminated oysters.

* * * * *

Uncooked oysters are thus to be regarded as a possible source of typhoid fever.

It is a very important point to determine to how great a danger the public is exposed from this source. Is the distribution of typhoid by oysters a rare incident, or is it a constant and considerable danger? These questions are being everywhere asked. Upon this matter at present little can be given beyond personal opinion. But the question is such a vital one that a word of personal opinion here may perhaps be pardoned.

In the first place, it appears evident that the public opinion at first exaggerated the amount of the danger. The lot of oysters sent to Wesleyan was very thoroughly infected, but there is no good evidence as yet that other lots of oysters from the same place were equally dangerous. The oysters sent to Amherst were probably also infected, but these probably belonged to the same lot as those sent to Middletown. Beyond this it has as yet been impossible to trace with certainty other instances of typhoid to the Fair Haven oysters. If it were true that all the oysters fattened at the same place were similarly infected, it would be expected that quite a number of cases of the disease should be traceable to the oysters. In New Haven especially, where the Fair Haven oysters are used largely, there would presumably have been found an exceptionally large amount of typhoid. There has been some considerable typhoid in the city during the months of October and November, and in a few cases it has been presumably traced to oysters, as shown elsewhere in the report of the State Board of Health. But there is hardly the amount that would be expected if the oysters were all subject to a contamination such as that which affected those sent to Middletown. Indeed, the consideration of the conditions at the oyster beds would lead to the belief that the contamination of the oysters would be exceptional. Where the oysters were placed near the mouth of a small sewer, and when this sewer came from a house containing typhoid patients, the danger of their contamination would be at its maximum. Should they chance to be placed near the mouth of a large city sewer, the danger, though a more constant one, would be much less likely to produce any considerable contamination of a large lot of oysters, since the typhoid material would be mixed by so much water as to distribute it widely and in a very dilute condition. Only an occasional oyster would thus be infected. At Fair Haven, however, when a proper eddy brought the material from the vicinity of the sewer toward the oysters, the chances were good for the whole lot to become infected. Perhaps oysters might lie in the same place many a time before and

after, and not be injured thereby, because no eddy happened at the right moment to sweep typhoid material in their direction. The danger from typhoid infection is, therefore, probably somewhat exceptional, even under the conditions existing. Where the oysters are fattened at a distance from sewers the danger practically disappears, and even where they are open to infection from large overflow of a city sewer, the danger is certainly less than in the fortunately exceptional case of the oysters in the vicinity of a private sewer containing typhoid excretions.

The extent of the danger will plainly depend very largely upon the question whether the typhoid germs actually grow and multiply in the oyster, or whether they simply remain alive there for some time. It may be that the oysters furnish a good culture ground for the typhoid germs, which grow rapidly when once within the shell. This would, of course, greatly increase the danger, for one lot in a fattening bed might infect others. On the other hand, it may be that the germs do not grow in the oysters, but that only such individual bacteria as find entrance remain alive. In this case the infectious material would be found only in the juices in the shell and adhering to the outside of the shell. The danger would, of course, be much less. Which of these two conditions represents the facts cannot at present be stated. It is hoped that experiments now in progress will settle the matter. But according to either view, oysters may serve as a means of transportation of typhoid wherever they are fattened in the vicinity of sewers; and wherever they are placed in the mouths of freshwater streams for this fattening process there will always be the chance of contamination from sewage. Few of the freshwater streams in the vicinity of our large cities fail to have sewage emptying into them. While, then, we cannot determine the extent of the danger, and while, in the opinion of the writer the danger is not very great, it must be recognised as a danger. Probably not a few of the obscure cases of typhoid which develop each fall shortly after the oyster season opens, and which cannot be traced to any source, may be due to contamination through oysters. It is, of course, impossible to determine the truth of this suggestion, but now that the possibility has been pointed out, we may hope that our health boards may in future years be able to determine the real extent of the danger. One thing is sure: The public health is placed in jeopardy when oyster dealers, for the sake of producing plumpness, place oysters in the mouths of freshwater creeks in close proximity to sewers. It is hoped that one result of the epidemic at Wesleyan will be to lead to greater care in this direction, both on the part of the oyster dealers themselves, whose business will certainly be greatly injured by the repetition of such outbreaks of typhoid as that at Wesleyan, and on the part of our boards of health, who have in their keeping so much of the public weal.

Wesleyan University,
Middletown, Conn.,
December 11th, 1894.

Dr. C. A. Lindsley,
Secretary of State Board of Health.

November 26th, 1894.

Dear Sir,—I can at present only give a preliminary statement in regard to the question of the growth of the *B. typhi abdominalis* in oysters, my investigations not yet having been completed.

The question submitted to me for investigation was this : Can the *B. typhi abdominalis* live and multiply in oysters ?

Two series of experiments were performed.

First—Oysters were inoculated with a pure culture of the *B. typhi abdominalis* after removing the upper shell.

Second—A small opening was made in the free end of the shells of several oysters, and through this opening a pure culture of the *B. typhi abdominalis* was injected. The oysters in these second series were presumably alive.

After forty-eight hours plates were made from the oysters in each series, and in each the *B. typhi abdominalis* were detected. That is, the *B. typhi abdominalis* will live in an oyster for forty-eight hours. Whether it will multiply or not will require a longer time to determine, since in some of the oysters examined there were other kinds of bacteria growing, which made the examination much more difficult.

I have not attempted to determine whether the *B. typhi abdominalis* will live in salt water or not, as the experiments of Freytag show that it will live six months in a concentrated solution of salt. Foster has also shown that the *B. typhi abdominalis* will resist the action of a saturated solution of salt for weeks, and even for months.

The conditions of communication of typhoid fever by oysters in such an instance as the Middletown epidemic require that the *B. typhi abdominalis* should live in salt or brackish water for some time at least; that it should be deposited by the current on the oysters, and that, having been introduced into the oysters, it should live in them until they are eaten—in this case, twenty-four to forty-eight hours.

That the *B. typhi abdominalis* will live in salt water for some weeks and in oysters for at least two days I believe proven.

I am still engaged in studying the growth of the *B. typhi abdominalis* on oysters, and hope later to send you a report of my work.*

Very truly yours,

CHARLES J. FOOTE.

* A later report entitled "A Bacteriological Study of Oysters with Special reference to them as a Source of Typhoid Infection," by Charles J. Foote, Demonstrator of Bacteriology, of Yale University, is contained in the 18th Annual Report of the State Board of Health of Connecticut, 1896.

APPENDIX No. 4.

EXTRACTS FROM THE PROCEEDINGS OF THE ACADEMIE DE MÉDECINE
OF PARIS, RELATING TO THE SPREAD OF DISEASE THROUGH THE
AGENCY OF OYSTERS.

Académie de Médecine, 1^o Séance du 2 juin 1896.

M. Cornil : J'ai l'honneur de donner connaissance à l'Académie d'un très intéressant mémoire de M. le Dr. Chantemesse, sur les *huîtres et la fièvre typhoïde*.

M. Chantemesse a connu plusieurs personnes qui, soucieuses de leur santé, et veillant avec soin sur leur eau de boisson, avaient contracté la fièvre typhoïde en mangeant sans défiance des huîtres souillées par des eaux contaminées. Témoin l'observation suivante, qui a presque la rigueur d'une expérience de laboratoire.

" Dans une petite ville de l'Hérault, Saint-André-de-Sangonis, où le dernier cas de fièvre typhoïde remontait à un an environ, un marchand reçut le 15 février dernier une bourriche d'huîtres venant de Cette. Ces huîtres furent vendues et mangées crues par quatorze personnes de la ville.

" Toutes celles-ci ont été malades, et dans les six maisons où l'on a consommé les huîtres, les membres de la famille et les domestiques qui n'en avaient pas mangé, n'ont éprouvé aucun malaise.

" Sur les quatorze personnes atteintes, huit en ont été quittes pour des accidents relativement bénins, qui ont duré deux ou trois jours et qui ont consisté en douleurs gastriques, vomissements, diarrhée, borborygmes, inappétence et malaise général.

" Quatre autres, les plus jeunes, qui n'avaient pas fait une grande consommation d'huîtres, ont éprouvé des accidents longs et tenaces, qui ont persisté de quinze à vingt-cinq jours ; les selles étaient infectes, pénibles, d'apparence dysentérique ; le ventre était ballonné, plein de gargouillements et douloureux à la pression ; les malades souffraient d'un malaise général et d'une grande prostration.

" Les deux autres personnes, une jeune fille de vingt ans et un jeune homme de vingt et un ans, ont été atteintes d'une fièvre typhoïde exceptionnellement grave. La jeune fille a succombé."

Les détails cliniques de cette observation ressemblent étroitement à ceux qui font suite d'ordinaire aux infections produites par les mollusques. Le poison absorbé le même jour, à la même dose sensiblement, par diverses personnes, traduit ses effets suivant l'aptitude réactionnelle des individus.

L'épidémie attribuée aux huîtres de Cette pouvait-elle être provoquée par des huîtres de toute provenance, achetées au hasard chez les marchands de Paris ?

Était-il possible d'en acquérir la certitude expérimentale ? C'est le problème que M. Chantemesse a cherché à résoudre. Il a acheté, chez un des principaux marchands de Paris, des huîtres fraîches de diverses provenances, à leur arrivée à Paris, au moment où elles allaient être livrées à la consommation. Il choisit des Marennes vertes et blanches, des huîtres dites anglaises, des huîtres d'Ostende, des huîtres portugaises, etc. Elles étaient vivantes, bien conservées et d'aspect appétissant. Soumises, avec l'aide de son externe, M. d'Avellar, à un examen

bactériologique méthodique dans le laboratoire, il fut reconnu que toutes renfermaient beaucoup de germes et bon nombre étaient contaminées par la présence de coli-bacilles. Quelques-unes de ces huîtres, vivantes, ont été placées dans de l'eau de mer, souillée intentionnellement de déjections typhiques et de bacilles typhiques. Après un séjour de vingt-quatre heures dans cette eau, elles ont été retirées et conservées, fermées, pendant vingt-quatre heures encore, c'est-à-dire le temps que nécessite d'ordinaire le voyage des huîtres, de leur parc aux lieux de consommation. Après ce temps, les huîtres étaient encore vivantes, sans odeur particulière, et de belle apparence. L'examen bactériologique a montré qu'elles renfermaient, dans leur corps et dans l'eau qui les baignait, des coli-bacilles et des bacilles typhiques vivants.

L'analyse bactériologique confirmait donc pleinement les données de l'épidémiologie.

L'huître de bonne qualité est un excellent aliment et parfaitement inoffensif; son caractère de nocuité accidentelle lui vient des souillures auxquelles on l'expose. Le danger est moindre dans les contrées où l'huître est consommée cuite; il devient grave dans les pays, la France, l'Angleterre, l'Italie, etc., où l'huître est mangée crue. La souillure la plus fréquente est contractée dans les parcs d'engraissement ou de réserve. Ceux-ci sont installés, pour la plupart, au bord de la mer, près de l'embouchure des rivières, des canaux, des ruisseaux qui charrient des germes et des déjections de toutes sortes.

Dans ce mélange d'eau de mer et d'eau douce chargée de matières organiques, l'huître prospère mais se contamine facilement. Dans le midi et l'ouest de la France, on pourrait citer nombre de parcs réputés les plus favorables à l'engraissement, ou les faits se passent de la façon que j'indique. A Cette, d'où sont venues les huîtres, cause de l'épidémie de Saint-André-de-Sangonis, le canal qui fait communiquer l'étang de Thau avec le port traverse la ville et reçoit en abondance des déjections et des ordures; il donne aussi asile aux huîtres qui, placées dans de grandes caisses, y sont communément immergées. A l'embouchure de la Vilaine, le parc de Péneston est baigné constamment par les eaux du fleuve qui transporte les déjections de Redon, de Rennes et de bien d'autres agglomérations humaines.

Mêmes réflexions, pour les parcs du Morbihan situés sur la rivière d'Auray et sur la rivière de Vannes, etc.

Des faits très analogues à ceux-ci ont été constatés à l'étranger, en ce qui concerne la transmission de la fièvre typhoïde et du choléra.

Déjà, en 1880, dans un Congrès, de la *British Medical Association* tenu à Cambridge, Sir Cameron avait indiqué ce mode de propagation de la fièvre typhoïde.

Dans ces dernières années, les publications sur ce point sont devenues fréquentes. Qu'il suffise de citer les observations du Dr. Conn (*New York Evening Post*, 1894), de William Broadbent (*British Medical Journal*, 1895) et celles du Dr. Johnston-Lavis, faites antérieurement à Naples, etc.

En Amérique, les faits de transmissions infectieuses par les huîtres sont devenus assez inquiétants, pour que le gouvernement se préoccupât des mesures préventives soumises aux délibérations de la "State Fish and Game Commission."

Il est donc souhaitable que les mesures de surveillance prises pour assurer l'innocuité des viandes de boucherie et des abattoirs, s'étendent à cette autre partie de l'alimentation constituée par les mollusques mangés crus. L'importance de cette alimentation est grande, puisque le chiffre des huîtres consommées à Paris, chaque année, dépasse, paraît-il, deux cents millions.

La mesure principale devra porter sur la surveillance des parcs et des réserves.

Si l'on ne peut supprimer la contamination des parcs, peut-être serait-il possible d'envoyer les huîtres, quelques semaines avant leur consommation, en mer, sur les côtes sauvages de Belle-Isle, de la Bretagne, etc., où elles se dépouilleraient de leurs impuretés. Il y a, en effet, dans les pratiques actuelles, un danger réel et grave, et qui peut être évité.

Je ne puis qu'approuver cette manière de voir et inviter l'Académie, maintenant que quelques mois nous séparent encore de l'époque à laquelle reprend la consommation des huîtres, à inviter les pouvoirs publics à se préoccuper de donner satisfaction aux desiderata si justement exprimés par M. Chantemesse.

2° Séance du 9 juin 1896.

At this sitting of the Academy, M. Joannes Chatin read a paper entitled *Sur la Nocivité des Huîtres*, and after dealing at some length with the natural history of the oyster, he gave an account of an occurrence of disease which, as far back as 1816, is alleged to have followed on the consumption of oysters in five different towns and localities; the oysters in question having been stored where they were exposed to the contents of drains and other gross pollution. He then proceeds as follows :—

Bien certainement, nos parcs actuels sont installés dans des conditions toutes différentes; je ne doute pas que la plupart d'entre eux ne soient irréprochables. Cependant les exemples cités par M. Chantemesse montrent qu'il en est, au moins quelques-uns, dont la situation et l'aménagement doivent être sérieusement examinés.

Loin de moi la pensée de créer des entraves à l'industrie ostréicole, industrie particulièrement intéressante, digne de la sollicitude des pouvoirs publics, puisqu'elle s'efforce de développer, non sans difficultés, une branche importante de notre fortune nationale. Les ostréiculteurs seront les premiers à comprendre tout ce qu'ils gagneront à des améliorations, qui achèveront d'affirmer la valeur et la qualité de leurs produits.

S'il était besoin de justifier les précautions que nous jugeons nécessaires, il nous suffirait de rappeler combien les mœurs de l'Huître l'exposent, le cas échéant, à une infection microbienne intensive.

Sédentaire, plus sédentaire que la Moule, elle se trouve indéfiniment exposée aux mêmes contacts, aux mêmes courants, aux mêmes causes de souillure.

D'autre part, le fonctionnement de ses organes respiratoires provoque un incessant appel d'eau qui baigne ses tissus, y charriant sans relâche des matières minérales et organiques.

Il suffit de voir l'eau sortir des valves du Mollusque, absolument clarifiée et filtrée, pour soupçonner ce qu'elle lui abandonne, même en tenant compte de ce qui peut être rejeté dans le milieu cosmique, sous forme d'excréments, de grumeaux agglutinés par le mucus palléobranchial, etc. Il est impossible d'apprécier, soit quantitativement, ce qui reste dans l'organisme.

Aussi est-on en droit de se demander comment l'ingestion d'Huîtres, parquées dans des conditions suspectes, ne provoque pas plus souvent des accidents. L'explication de cette innocuité reside, peut-être, dans une curieuse particularité biologique.

Ainsi que je l'ai établi précédemment,* la phagocytose se manifeste chez l'Huître avec une activité exceptionnelle. Elle s'exerce moins par les amibocytes de l'hémolymphe que par les cellules conjonctives, perpétuellement en état de mobilisation. De véritables colonnes de phagocytes parcourent ainsi le milieu intérieur du Mollusque, et l'assainissent sans interruption; se frayant un passage à travers les tissus, écartant ou dévorant les assises épithéliales, ces cellules migratrices gagnent l'extérieur pour y porter les déchets et les microorganismes dont elles se sont chargées, chemin faisant.

Mais, si puissante que soit l'intervention des phagocytes, elle ne suffira pas toujours à faire disparaître les germes pathogènes ou à atténuer l'effet de leur pénétration.

Nous devons donc veiller à préserver l'Huître de tout contact impur : sans être nocive par elle-même, elle peut le devenir par le milieu dans lequel on la place.

Pour y remédier, les mesures sont faciles à instituer. Presque partout elles ont été formulées dans des termes identiques; on peut facilement s'en convaincre par la lecture des nombreux documents publiés à l'étranger durant ces dernières années.

Il appartient à la Commission d'examiner quelles prescriptions sont applicables aux parcs du littoral français.

Si j'ai demandé aujourd'hui la parole, c'est surtout en vue d'apporter quelques contributions biologiques à l'étude d'un sujet qui s'impose tout particulièrement à l'attention de l'Académie.

Sur un mémoire de M. CHANTEMESSE, relatif aux huîtres dans leurs rapports avec la fièvre typhoïde, au nom d'une Commission composée de MM. LABOULBÈNE, A. GAUTIER, J. CHATIN et

CORNIL, rapporteur.

Dans la séance du 2 juin l'Académie a entendu une communication de M. Chantemesse sur les dangers que présentent les huîtres mangées crues, au point de vue de la propagation de la fièvre typhoïde. Il ne suffit pas, en effet, pour se garantir contre cette maladie, de surveiller attentivement la qualité de l'eau de boisson, mais aussi de tous les aliments mangés crus qui peuvent être contaminés par de l'eau contenant des espèces bactériennes nocives. Telles sont les huîtres lorsqu'elles ont séjourné dans des parcs, au milieu d'une eau souillée par les égouts et impuretés provenant des eaux usées des villes et villages voisins à l'embouchure des fleuves et au-dessous des habitations dans les ports de mer.

M. Chantemesse a cité comme exemple une épidémie, observée en février 1896, de la petite ville de Saint-André-de-Sangonis où des huîtres provenant de Cète, mangées par quatorze personnes, ont causé chez toutes des accidents gastro-intestinaux; chez quatre d'entre elles, des accidents fébriles avec selles infectes, d'apparence dysentérique, balonnement et gargouillement du ventre ont persisté de quinze à vingt jours; et enfin deux de ces personnes, une jeune fille de vingt ans et un jeune homme de vingt-un ans, ont succombé à une fièvre typhoïde exceptionnellement grave.†

* Joannes Chatin. De la phagocytose chez les huîtres. *Comptes rendus de l'Académie des Sciences*, 1896.

† Dr. Chantemesse says: "La jeune fille a succombé." At the time of writing his paper, there appears only to have been one fatal attack. See page .

M. Chantemesse a constaté que beaucoup d'huîtres achetées à Paris, et de très belle apparence, contenaient dans l'eau de leurs branchies beaucoup de germes et même des coli-bacilles. Il a vu qu'en laissant plusieurs jours des huîtres vivantes au milieu d'une eau de mer polluée de bacilles et de déjections typhiques, elles vivaient très bien avec leurs caractères normaux et sans odeur particulière. Il va sans dire que leurs branchies, examinées vingt-quatre heures après qu'elles avaient été retirées de cette eau, étaient remplies de bacilles du côlon et de la fièvre typhoïde. Elles n'en avaient pas moins conservé leur belle apparence.

Dans les parcs où les huîtres sont engraisées, et qui renferment un mélange d'eau de mer et d'eau douce souvent polluée par des déjections, elles prospèrent, mais se contaminent souvent. On peut même dire qu'elles s'engraissent d'autant plus facilement que leur parc reçoit plus de matières organiques assimilables.

A Cette, d'où étaient venues les huîtres consommées à Saint-André-de-Sangonis, le canal qui fait communiquer l'étang de Thau avec le port, traverse la ville et reçoit en abondance des déjections et des ordures; des huîtres placées dans de grandes caisses, y sont communément immergées.

Des souillures analogues pourraient être à craindre dans un certain nombre de parcs, si l'on n'y prenait pas garde.

Des faits analogues ont été constatés à l'étranger, en Angleterre surtout et en Amérique; mais le danger au Nouveau-Monde est moindre, car le plus souvent les huîtres sont consommées cuites. Cependant, les Américains laissent quelquefois séjourner l'huître dans de l'eau douce avant de les servir.

Chez nous, les amateurs d'huîtres multiplient les dangers possibles de leur consommation, en avalant toute l'eau contenue dans leur coquille avec tout les débris et souillures qui y sont enfermés.

L'huître vivante est assurément un des plus agréables et des plus nutritifs de nos aliments. Bouchardat dit, avec raison, que des huîtres mangées avec des tartines de pain beurré et relevées par une bouteille de vin de Chablis constituent un repas complet.

On doit reconnaître aussi que les accidents gastro-intestinaux ou typhoïdiques consécutifs à son ingestion sont très rares, presque exceptionnels.

Mais comme ces accidents sont aussi indéniables et que leur cause nous est connue, puisqu'elle consiste dans un vice de la conservation de l'huître et dans la souillure de l'eau des parcs, il est nécessaire d'y remédier.

Nous vous avons proposé, M. Chantemesse et moi, de demander au gouvernement de faire surveiller les parcs et réserves où les huîtres sont conservées, et lorsque ces parcs n'inspireraient pas toute confiance au point de vue de la pureté de leur eau, d'envoyer les huîtres se dégorger pendant quelque temps avant leur consommation, en mer, sur des côtes battues par une eau pure, comme à Belle-Isle, sur les côtes de Bretagne, etc.; on éviterait de cette façon un danger, exceptionnel je le reconnais, mais qui peut être suivi de graves conséquences.

La communication de M. Chantemesse a déterminé notre savant collègue M. J. Chatin à donner à l'Académie une étude sur l'histoire naturelle de l'huître, qui renferme un grand nombre de faits très intéressants et que nous avons tous applaudie.

M. Chatin ne doute pas que l'huître puisse devenir très nocive lorsqu'elle séjourne dans une eau adultérée par des déjections et il nous a cité un exemple d'épidémie très grave survenue par la consommation des huîtres ayant séjourné dans les fossés d'une citadelle qui recevaient le contenu des fosses d'aisances.

M. Chatin a examiné la possibilité du danger de l'huître pendant sa période de reproduction, question qui avait été soulevée en séance par notre éminent collègue M. A. Gautier.

Il est d'observation banale et populaire que les huîtres ne doivent pas être mangées pendant les mois de mai, juin, juillet et août, et, en fait, on s'en abstient presque totalement pendant la fin du printemps et pendant tout l'été.

Cette période correspond précisément avec celle du frai, et M. A. Gautier nous a fait remarquer que beaucoup de poissons, crustacés, mollusques, etc., fabriquent, pendant le frai, des toxines spéciales et en particulier des lécytines, qui les rendent dangereux pendant le temps de leur reproduction.

Les inconvénients de la consommation de l'huître pendant les mois d'été doivent-ils être mis sur le compte du frai ou doivent-ils être attribués simplement à ce que l'eau des parcs est plus chargé d'impuretés et plus nocive pendant la saison chaude ? C'est là ce que nous devons nous demander.

M. J. Chatin pense que les huîtres consommées de mai à septembre, en état de sous-activité reproductive, n'offrent aucun danger.

On en a fait l'expérience dans les stations du littoral où l'on autorise cette consommation estivale.

Mais lorsque la reproduction est en pleine activité, les huîtres revêtent un aspect laiteux ou ardoisé dû au mélange de mucus et des œufs, ou à la présence de larves brunes qui est plus ou moins repoussant.

M. Gautier est moins affirmatif et il pense, d'après ses observations, que certaines huîtres peuvent, surtout au moment du frai, donner lieu à des accidents toxiques.

L'intérêt même de l'ostréiculture fait une loi de ne pas détruire à cette époque ces mollusques pour la reproduction même de l'espèce.

Tout concourt donc à proscrire ou à limiter le plus possible la consommation des huîtres pendant les mois de la saison chaude : l'intérêt de leur conservation aussi bien que celui des consommateurs.

Mais le plus grand danger de l'alimentation par les huîtres en été nous paraît résider dans la souillure par l'eau des parcs. L'élévation de la chaleur du milieu aqueux est, en effet, beaucoup plus favorable que la température hivernale, à la reproduction rapide des microbes pathogènes qui s'y trouvent.

Ils entrent, en effet, dans la coquille, remplissent les lames branchiales et quand l'huître referme ses valves, ils sont transportés avec elle sur le marché où elle est consommée. En hiver, les eaux des parcs sont aussi contaminées, mais les microbes sont moins nombreux, en moindre activité reproductrice, la température aux environs de 0 degré ou jusqu'à 10 degrés, les mettant dans un état de repos annihilant ou retardant leur faculté germinative. Pendant le transport en chemin de fer, dans les entrepôts ou marchés des villes, ils sont soumis à la même basse température qui les place dans de mauvaises conditions de pullulation. Si des microbes pathogènes existent dans les lames de l'huître en hiver, ils y sont dans un état de vie et de nocivité très inférieur à ce qui se passerait en été.

Aussi, sommes-nous persuadés que la nocivité de l'huître en été, d'observation vulgaire et consacrée par la croyance populaire, a sa cause principale dans la plus grande abondance et dans la plus grande virulence des microbes contenus dans les parcs à huîtres pendant la saison estivale.

Loin de nous la pensée de porter la moindre atteinte à l'ostréiculture française, branche importante de notre commerce et que le gouvernement a le devoir de protéger ; mais il est dans son intérêt bien compris

de la prévenir, de la surveiller et de demander au gouvernement d'exiger qu'avant d'être livrées à la consommation, les huîtres de certains parcs notoirement contaminés, soient mises à dégorger, pendant plusieurs jours, sur des côtes où l'eau de mer est pure.

Nous savons, en effet, avec quelle facilité l'huître se débarrasse des corps étrangers, des algues microscopiques et des bactéries qu'elle détruit, en s'assimilant les particules nutritives qui y sont contenues.

M. J. Chatin nous a montré que la phagocytose s'y exerce avec une activité tout à fait exceptionnelle par les globules blancs et les cellules mobiles du tissu conjonctif. "De véritables colonnes de phagocytes" parcourent ainsi le milieu intérieur du mollusque et l'assainissent sans "interruption, se frayant un passage à travers les tissus, écartant ou "dévorent les assises épithéliales; ces cellules migratrices gagnent "l'extérieur pour y porter les déchets et les microorganismes dont elles "se sont chargées chemin faisant."

Nous sommes donc persuadés qu'il suffira de quelques jours dans une eau de mer pure pour que l'huître rejette au dehors toutes les particules nocives qu'elle pourrait contenir.

Mais cette précaution est nécessaire pour éviter des accidents rares, il est vrai, mais possibles. Comme nous sommes séparés par deux mois encore de la saison où les huîtres commencent à se vendre, on peut d'ici là prendre les précautions et mesures nécessaires.

C'est pourquoi nous vous proposons de voter les conclusions suivantes :

L'Académie de médecine, convaincue que la consommation d'huîtres ayant séjourné dans un parc dont l'eau est polluée peut déterminer des accidents gastro-intestinaux et même la fièvre typhoïde avec ses graves conséquences, émet le vœu que l'autorité compétente fasse surveiller l'aménagement des parcs du littoral, ainsi que les importations étrangères, et exige que les huîtres provenant de localités reconnues contaminées soient placées, pendant huit jours avant leur vente, sur un point de la côte baigné par l'eau pure de mer.

Les conclusions du présent rapport, mises aux voix, sont adoptées.



